3. Master caution/warning light

   a. Advises the pilot or CPG that a caution/warning/advisory panel light has illuminated.

   b. Located on the master caution/warning panel in each crewstation.

   c. Description

      (1) Amber in color

      (2) Flashes when any caution/warning/advisory panel light comes on.

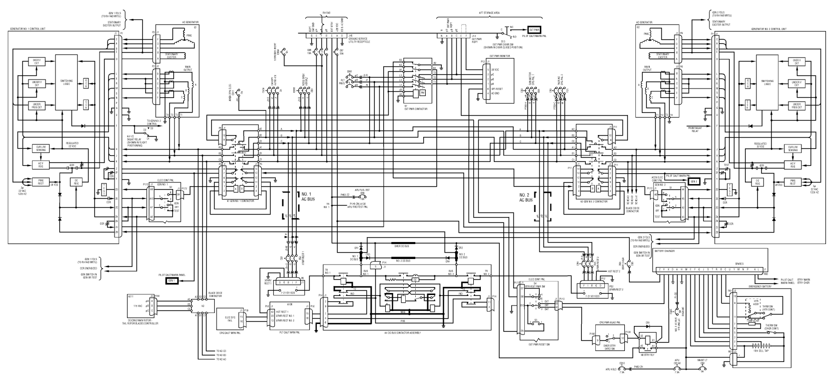
4. The generators and GCUs are tested by the FD/LS when the initiated FD/LS 18 maintenance mode test is selected.

   a. P1, pin e, and P7, pin e, are RECTIFIED PMG DC VOLTAGE (28 VDC) signals for generator 1 and 2, respectively. These monitored points are connected to the left and right forward avionics bay multiplex remote terminal unit type I, respectively.

   b. P1, pin a, and P7, pin a are the monitor points for the generator control switch GEN and TEST positions for generator 1 and 2. These monitored points are connected to the left and right forward avionics bay multiplex remote terminal unit type I.

   c. P1, pin E, and P7, pin E, is the GCU stationary exciter control winding output for generator 1 and 2. These monitored points are connected to the left and right forward avionics bay multiplex remote terminal unit type I.

AH-64A ELECTRICAL SYSTEM SCHEMATIC



NOTES

WARNING

ELECTRICAL POWER

Electrical power operating or maintenance procedures, practices or conditions, which, if not strictly observed, could result in injury or death to personnel. These WARNINGS must be strictly obeyed by all personnel.

A. AC electrical system normal operation initial conditions

1. The BATT/OFF/EXT PWR switch is in BATT position and the APU is operating.

2. The "helicopter is on the ground" signal is at the GCU J1, pin F.

3. The GEN 1 and GEN 2 switches are in the OFF/RESET position.

4. The GEN 1 and GEN 2 lights on pilot's caution/warning/advisory panel are illuminated.

5. Both AC generators are producing the PMG 3-phase, 22 VAC, 1225 HZ and supplying it to the respective GCU's.

6. The GCU's are rectifying the PMG 3-phase, 22 VAC, 1225 HZ into RECTIFIED PMG 1 DC VOLTAGE (28 VDC) and are providing it to the respective AC generator switches.

B. The GEN 1 and GEN 2 switches are individually placed and held in the TEST position.

1. The RECTIFIED PMG DC VOLTAGE (28 VDC) from the TEST terminals of the AC generator switches is applied to the GCU's.

2. The RECTIFIED PMG DC VOLTAGE (28 VDC) energizes the respective GCR. When the GCR's energize, each GCR's normally-closed contacts remove the short across the exciter DC control field windings and the AC voltage regulator's outputs are connected to the respective AC generator's exciter DC control field winding.

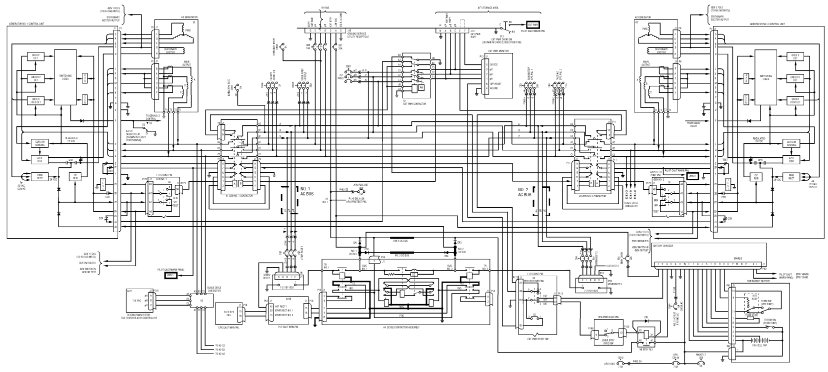
3. The AC generators now produce the 3-phase, 115/200 VAC, 400 Hz outputs for off-line monitoring by the respective GCU's fault sensing circuitry.

4. If the voltage and frequency are correct, the respective CCR energizes and connects RECTIFIED PMG DC VOLTAGE (28 VDC) to the TEST relays. The TEST relays energize and extinguish the respective GEN caution light.

5. The AC generator contactors do not energize and the AC generator's outputs are not connected to the AC essential buses during "TEST".

C. The GEN 1 and GEN 2 switches are released to the OFF/RESET position and the GEN 1 and GEN 2 caution lights illuminate.

AH-64A ELECTRICAL SYSTEM SCHEMATIC



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NOTES

D. Placing the GEN 1 switch in the GEN 1 position initiates the following sequence of events

1. When the GEN 1 switch is placed to the GEN 1 position, the RECTIFIED PMG 1 DC VOLTAGE (28 VDC) energizes GCR 1. When GCR 1 energizes, the GCR 1 normally-closed contacts remove the short across, and the AC voltage regulator 1 output is connected to, the AC generator 1 exciter DC control field winding.

2. The AC generator 1 now produces the 3-phase, 115/200 VAC, 400 Hz output for off-line monitoring by the GCU 1 fault sensing circuitry. If the voltage and frequency are correct, the CCR 1 energizes and connects RECTIFIED PMG 1 DC VOLTAGE (28 VDC) to the supply end of the generator contactor relay 1 (coil A). The control end has ground applied because the bus tie 1 relay is de-energized.

3. The generator contactor relay 1 (coil A) energizes and connects the 3-phase, 115/200 VAC, 400 Hz output from AC generator 1 to the AC essential bus 1. It also extinguishes the GEN 1 Caution light and opens the external power interlock.

4. Since the AC generator 2 is not providing an output at this time, the bus tie relay 2 (coil B) energizes. The bus tie relay 2 connects the AC essential bus 2 to the AC essential bus 1.

5. AC generator 1 is now supplying all AC electrical power for the helicopter.

E. Placing the GEN 2 switch in the GEN 2 position initiates the following sequence of events

1. When the GEN 2 switch is placed to the GEN 2 position, RECTIFIED PMG 2 DC VOLTAGE (28 VDC) energizes the GCR 2 (the GCR internal to GCU 2).

2. When GCR 2 energizes, the GCR 2 normally-closed contacts remove the short across, and the AC voltage regulator 2 output is connected to the AC generator 2 exciter DC control field winding.

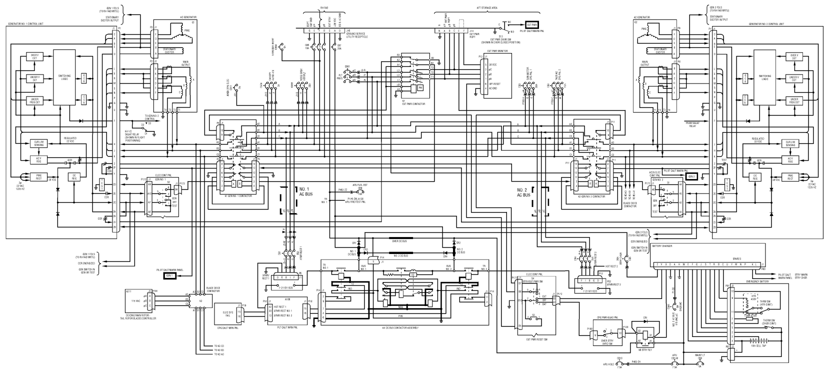
3. The AC generator 2 now produces the 3-phase, 115/200 VAC, 400 Hz output for off-line monitoring by the GCU 2 fault sensing circuitry. If the voltage and frequency are correct, the CCR 2 energizes and connects RECTIFIED PMG 2 DC VOLTAGE (28 VDC) to the supply end of the generator contactor relay 2 (coil A). The control end does not have ground applied because the bus tie 2 relay is energized.

4. CCR 2 opens the 28 VDC path to the bus tie relay 2 (coil B) supply end and it de-energizes.

5. De-energizing the bus tie relay (coil B) 2 disconnects AC essential bus 2 from AC essential bus 1 and completes the ground path to the control end of the generator contactor relay 2 (coil A).

6. The generator contactor relay 2 (coil A) energizes, and connects 3-phase, 115/200 VAC, 400 Hz from the AC generator 2 to AC essential bus 2. It also extinguishes the GEN 2 Caution light and opens the external power interlock.

AH-64A ELECTRICAL SYSTEM SCHEMATIC



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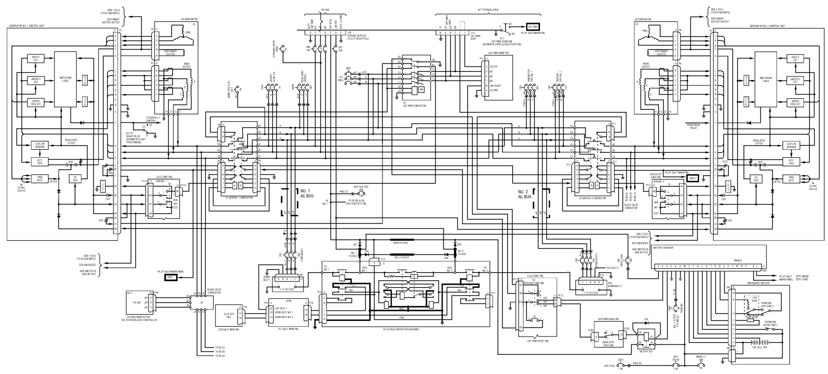
NOTES

F. Each generator now powers its respective AC essential bus, and also supplies power to open contacts of the opposite system's bus tie relay (coil B), in case of generator failure.

AH-64A ELECTRICAL SYSTEM SCHEMATIC



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NOTES

G. Analysis of AC electric system malfunctions

1. GEN caution light illumination may be caused by

   a. AC generator failure.

   b. GCU failure.

   c. AC generator contactor relay failure.

2. GEN 1 light illuminates (assume AC generator 1 fails)

   a. Generator electrical/mechanical failure possibilities

      (1) The permanent magnet could lose it's magnetism.

      (2) The 3-phase PMG windings are open or shorted.

      (3) The stationary exciter control winding is open or shorted.

      (4) The rotating exciter field, 3-phase AC, input windings are open or shorted.

      (5) If the exciter rectifier diodes are open or shorted, AC generator output is degraded.

      (6) The main rotating field, 4-pole, DC output windings may be open or shorted.

      (7) The main generator 3-phase output windings may be open or shorted.

      (8) The output terminal connections are loose, broken, or shorted.

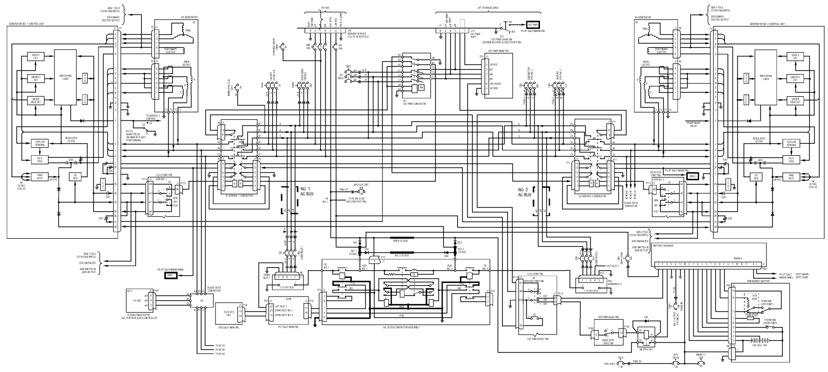
      (9) The rotation is stopped due to

         (a) Seized bearings.

         (b) Input shafting broken.

         (c) Transmission drive spline (frangible coupling) broken.

AH-64A ELECTRICAL SYSTEM SCHEMATIC



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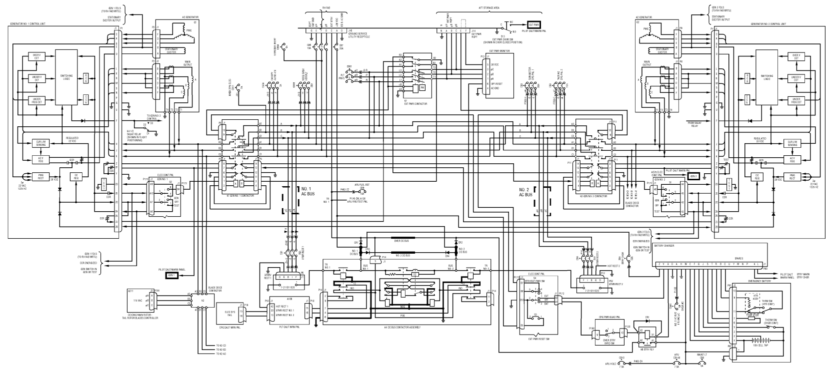
NOTES

b. Due to the AC generator 1 failure symptom, the GCU 1 fault sensing circuitry de-energizes the CCR 1.

(1) The normally-closed contact in the de-energized CCR 1 of GCU 1 connects a ground to the AC generator contactor 1, P5, pin 7, which illuminates the GEN 1 light on the pilot's caution/warning/advisory panel.

(2) The de-energized CCR 1 interrupts the RECTIFIED PMG 1 DC CONTROL VOLTAGE (28 VDC) to the AC generator contactor 1, P5, pin 1.

AH-64A ELECTRICAL SYSTEM SCHEMATIC



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NOTES

(a) The generator contactor relay (coil A) de-energizes and interrupts the AC generator 1 connection to AC essential bus 1.

(b) The bus tie relay 1 (coil B) is energized.

1) The bus tie relay 1 (coil B) control end (pin 4) is connected to ground via the normally-closed contacts (pins 5 and 6) of the generator contactor relay 1.

2) The RECTIFIED PMG 1 DC VOLTAGE (28 VDC) from the GCU 1 (pin j) is connected to pin 3 of the AC generator contactor 1, bus tie relay (coil B), via the normally-closed contacts (pins A2 and A3) of the external power contactor.

3) The RECTIFIED PMG 1 DC VOLTAGE (28 VDC) and DC essential bus 2 voltage are connected by isolation diodes inside the GCU 1. This ensures actuation voltage for bus tie operation independent of a failed AC generator or GCU.

(c) The bus tie relay 1 connects the two AC essential buses together.

(3) The AC generator 2 now supplies all AC power for the helicopter, both T/Rs for DC power conversion, and all three DC essential buses.

c. If the AC generator 2 fails, the preceding description applies, substituting the respective components.

d. If both generators fail there will be no AC power available for aircraft systems. Only the emergency DC system, powered by the aircraft battery, supplies the emergency DC bus in this situation.

3. GEN 1 light illuminates (GCU is suspect, a replacement AC generator did not remove the fault).

a. Fault detection circuit failures

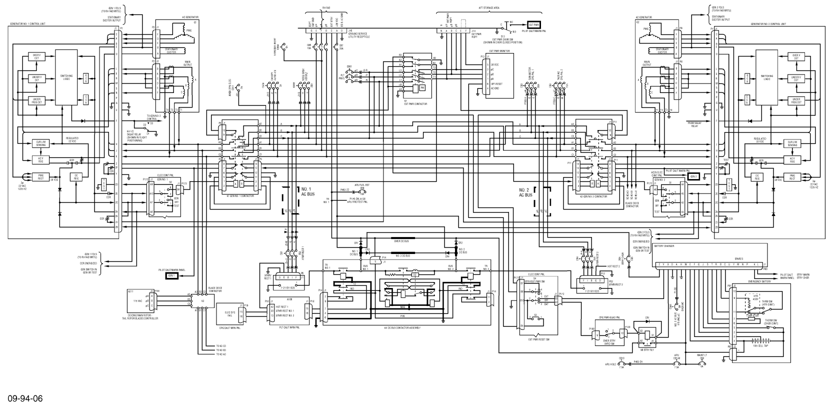
(1) Appear as AC generator failures and would prevent the AC generator from coming on-line for the following circuit failures

(a) AC voltage regulator.

(b) Overcurrent detector.

(c) Overvoltage circuit.

AH-64A ELECTRICAL SYSTEM SCHEMATIC



NOTES

(d) Undervoltage circuit.

(e) Underfrequency monitoring circuit.

b. Fault summing logic failures

(1) The AC generator may test properly; but, not come on line (CCR control logic failure).

(2) Appear as AC generator failures and would prevent the AC generator from coming on-line (GCR control logic failure).

c. Generator Control Relay (GCR) failures

(1) Appear as AC generator failures and would prevent the AC generator from coming on-line.

d. Contactor Control Rely (CCR) failures

(1) The AC generator may test properly; but, not come on line.

e. TEST relay failures

(1) The AC generator would operate normally; but, the GEN light would not extinguish

4. AC generator contactor 1 failure

a. Generator contactor relay (coil A) failure.

(1) The AC generator 1 could not connect to its bus.

(2) The GEN 1 caution light is illuminated.

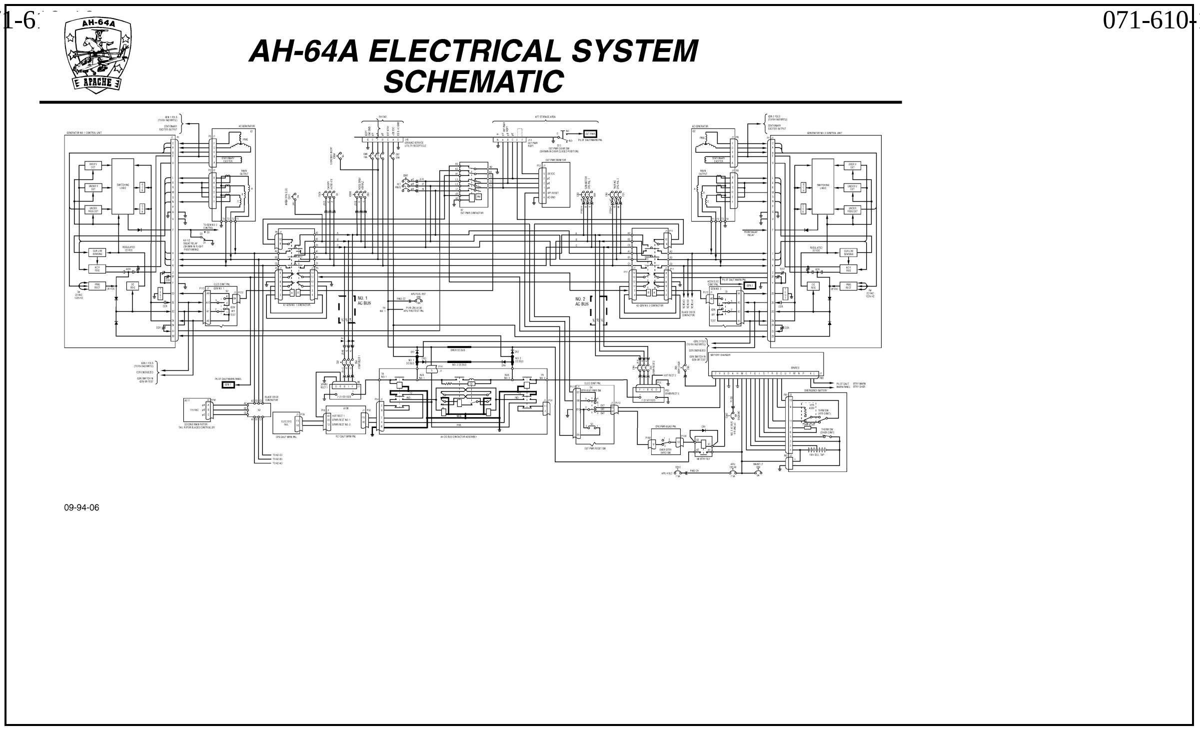
(3) The AC generator 2 could not supply the AC essential bus 1.

(a) The GCU 1 does not detect the fault.

(b) The open contacts of the CCR 1 (GCU pins j and k) prevent bus tie operating voltage from being available.

(4) Only by placing the GEN l switch in the OFF/RESET position can the GCU be de-energized. This energizes the bus tie relay 1 (coil B), and provides AC essential bus 2 power to the AC essential bus 1.

(5) If the generator contactor 2 (coil A) had failed, the symptoms of the AC electrical system 2 would correspond to those of the No. 1.



NOTES

b. Bus tie relay (coil B) failure.

(1) If the bus tie relay (coil B) fails after both systems are operating, normal generator operation is not affected. There is no indication of this failure if both AC generators and generator contactor relays (coil A's) continue to operate normally.

(2) If the AC generator 1 fails, the GCR 1 de-energizes and illuminates the GEN 1 caution light.

(3) With a defective bus tie relay (coil B) 1, the AC essential bus 2 cannot supply power to the AC essential bus 1. The pilot's RECT 1 caution light illuminates on the caution/warning/advisory panel.

(4) The corresponding failures in system No. 2 will cause corresponding symptoms in the AC electrical system 2.

c. Assume GCU 1 failure (there are many possible failure symptoms affected by this unit).

(1) An AC voltage regulator circuit failure is detected by the overvoltage or undervoltage detector circuits depending, on the failure symptom.

(a) If the AC voltage regulator fails to the high side, the overvoltage circuit will detect an AC generator overvoltage condition and will de-energize the CCR and GCR.

(b) If the AC voltage regulator fails to the low side, the undervoltage circuit will detect an AC generator undervoltage condition and will de-energize the CCR and GCR.

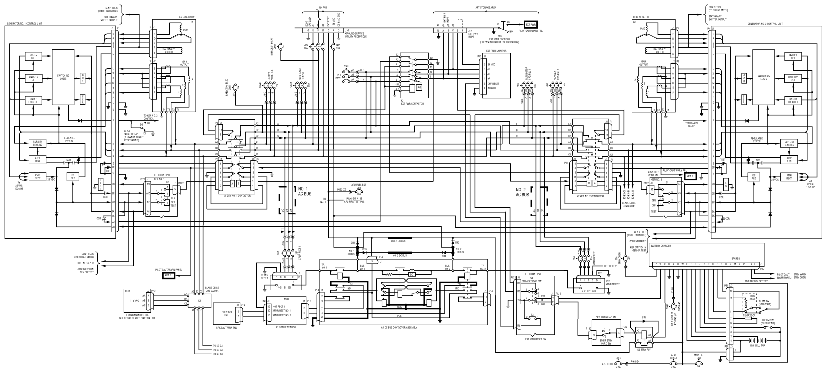
(2) Overvoltage or undervoltage circuit failure

(a) Is apparent if the circuit de-energizes the CCR and GCR.

(b) Is not apparent if either the CCR or GCR fails to function as a detector.

(c) May or may not be apparent if coupled with AC voltage regulator problems. Excessive or insufficient voltage can damage the helicopter and/or the electronic equipment. Due to the isolation diodes supplying the DC essential bus 3 and emergency DC bus power, the DC essential bus with the highest voltage supplies all of the power to the dependent buses. Typically, all LRUs will have internal DC voltage regulation and filtering to protect against unregulated DC supply voltage.

AH-64A ELECTRICAL SYSTEM SCHEMATIC



09-94-06

NOTES

(3) Individual failure of any of the three internal relays

(a) Test relay failure is not apparent until activation on the ground.

1) Test relay pins y and z connect ground to normally-closed contacts of the generator contactor relay (pins 7 and 8).

2) The de-energized generator contactor relay connects this ground to illuminate the GEN light on the caution/warning/advisory panel.

(b) GCR failure (This relay has two sets of contact pairs, plus the coil).

1) One pair of contacts applies and removes the short across the AC generator stationary control field winding. Failure of this pair prevents/interrupts AC generator 3-phase, 115 VAC, 400 Hz output.

2) The second pair connect and disconnect rectified PMG DC power to the first pair.

(c) CCR failure (This relay has four sets of contact pairs that can fail individually, there is also the possibility of the coil opening or the coil driver locking on).

1) Pins Y and f are the GCU connections to ground and the GEN caution light. The TEST relay duplicates this ground source only if the generator contactor relay is not energized. Failure of the CCR contact pair connected to this pin affects the lamp operation by locking it in one condition.

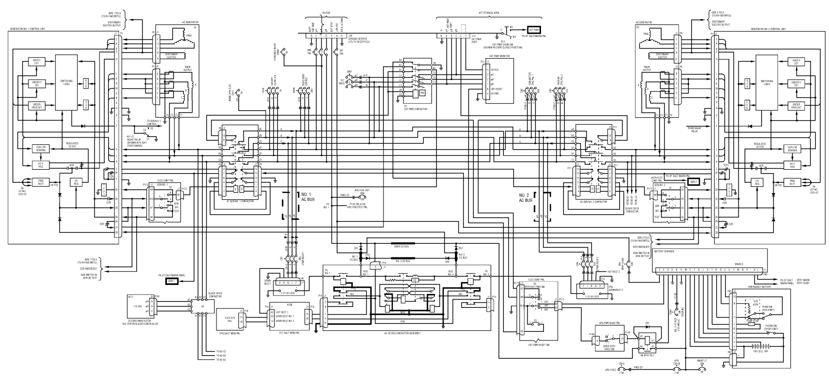
2) Pin e is the 28 VDC power contact for the generator contactor relay (coil A). Failure of the CCR contact pair connected to this pin could disable one AC essential bus, allow a faulty AC generator to remain on-line and prevent the bus tie relay (coil B) from energizing.

3) Pins j and k are the bus tie 28 VDC connection points for operation from the opposite AC essential bus. A failure of this pair could interrupt bus tie operation.

4) Connects the GCU internal ground to the internal fault logic reset functions.

071-610-10

AH-64A ELECTRICAL SYSTEM SCHEMATIC



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NOTES

5. General troubleshooting considerations

a. The following components can partially or completely fail.

(1) Electronic circuitry can fail, difficult to trouble shoot at the unit level.

(2) Relays

(a) Relays can have bad individual contact pairs.

(b) Relay contacts may not make contact at all.

(c) Excessive current may have fused the contacts so that they are always connected.

(d) The contact made may check out during a simple continuity test, but fail when high current is applied.

(e) The internal transient clipping diode across the relay coil may short and shunt actuation current, so that the relay is slow or unable to actuate.

(f) Relay coils may open or short.

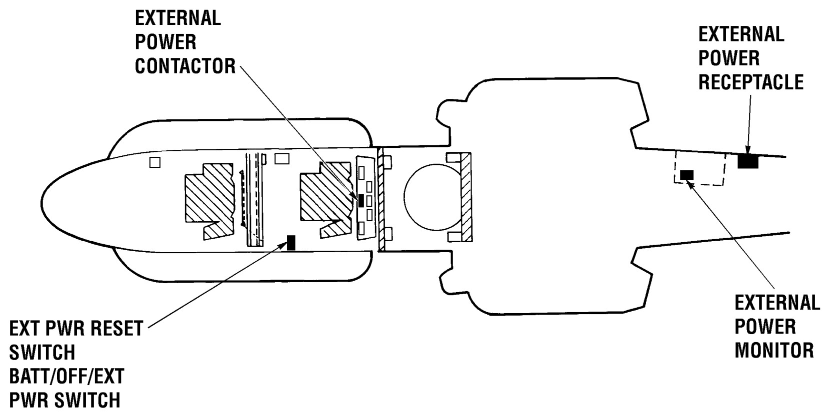
(3) Switches can have the same internal contact problem possibilities as relays.

(4) Mating socket pins, crimp splices, and solder joints can all have high resistances to high currents due to contamination (dirt, oil, arcing, etc.), and test good during low current continuity tests.

(5) Meters, test leads, pins, and other troubleshooting aids are always suspect and must be verified.

(6) Exposed conductors due to chaffed wiring insulation or broken wires shorting to a conductive surface, can be difficult to find with continuity test equipment. Such shorts inside a connector, or anti-chafe wrapping can be difficult to analyze in a stationary helicopter with no vibration or movement to reproduce flight failure conditions.

EXTERNAL AC ELECTRICAL POWER SYSTEM



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83-142C

NOTES

A. External power system - provides a means of connecting 3-phase, 115/200 VAC, 400 Hz electrical power from and external source, for systems operation and/or check out.

B. Features and capabilities

1. Checks, enables, and monitors external power connected to the AH-64A.

2. Monitors applied external power for the following faults

a. Over/undervoltage

b. Over/underfrequency

c. Phase sequence

d. Secure connection of external power plug at the external power receptacle, via an interlock circuit.

e. Electrically disconnects external power if a fault is detected.

f. All major components are LRUs.

C. Major external power system components

1. BATT/OFF/EXT PWR switch

2. External power receptacle

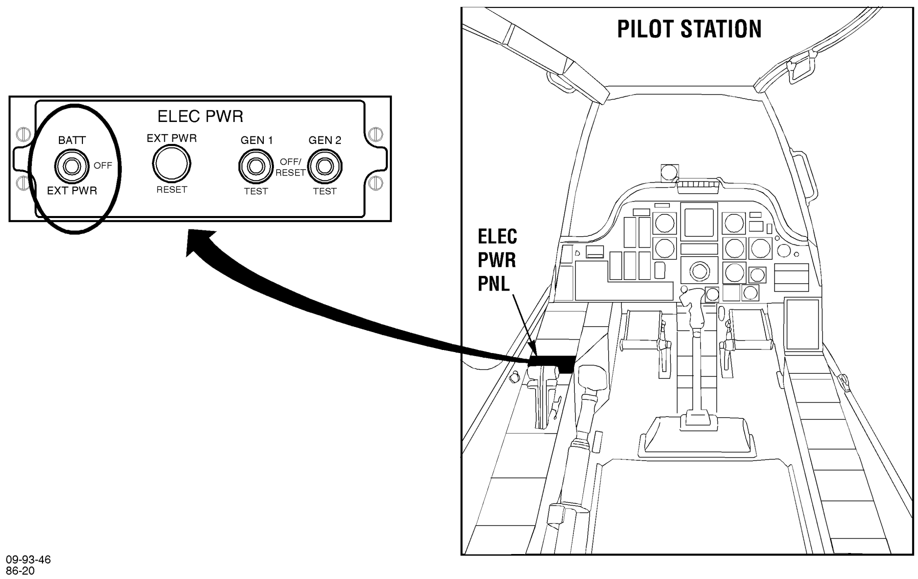
3. External power interlock switch

4. External power monitor

5. External power contactor

6. External power caution light

PILOTs ELEC PWR CONTROL PANEL



NOTES

D. Component description and location

1. EXT PWR RESET switch

a. When pressed, it resets the external power monitor fault sensing logic if external power is applied and is interrupted by the external power monitor fault sensing logic.

b. Momentary contact push button switch.

c. The electrical power control panel is mounted on the pilot's left console.

2. BATT/OFF/EXT PWR switch

a. Provides operational control of the external AC power system.

b. Located on the electrical power control panel in the pilot's left console.

c. Description

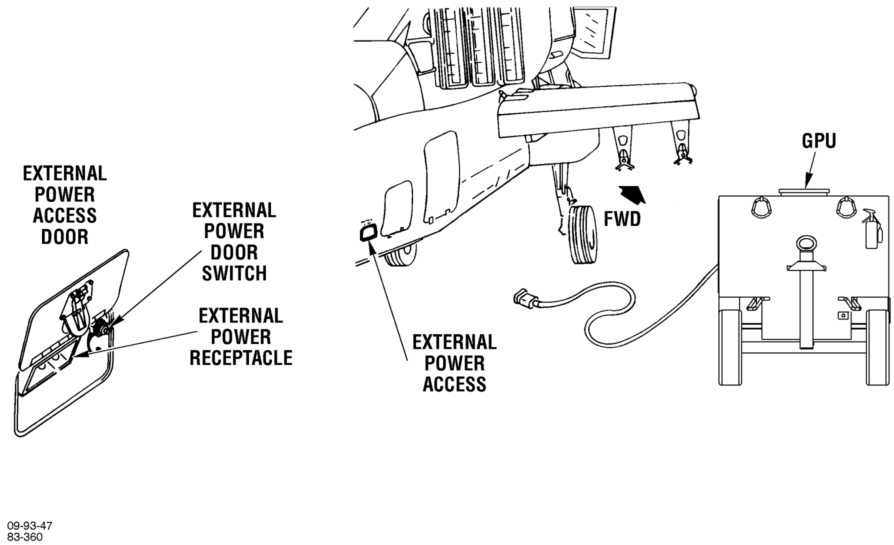
(1) Double-pole, double-throw, three-position toggle switch.

(2) The EXT PWR position permits connection of external power to AC essential bus 1 and 2, if the input voltage, frequency, and phase sequence are correct.

(3) The OFF position disconnects external power.

(4) The BATT position connects the helicopter battery to the DC emergency bus.

EXTERNAL POWER RECEPTACLE LOCATION



NOTES

3. External power receptacle

   a. Provides a means of connecting a 3-phase, 115/200 VAC, 400 Hz external power source to the aircraft.

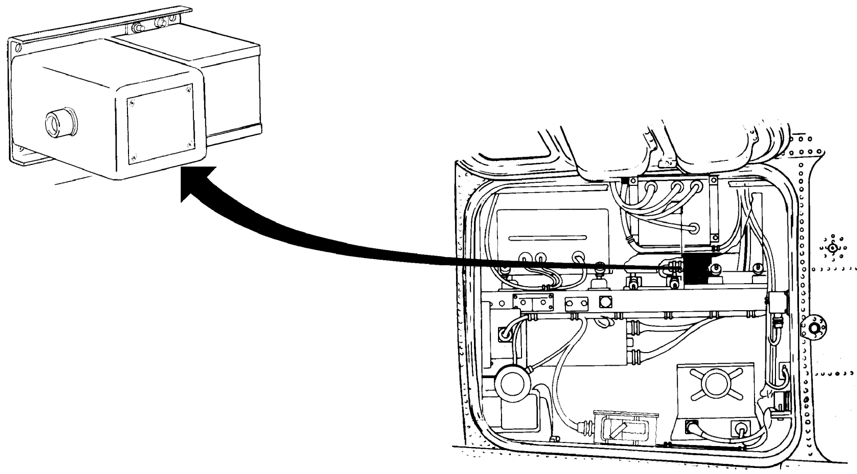
   b. Located behind the aft storage compartment, on the right side of the aircraft.

   c. Description

      (1) Rectangular in shape with six male pins. Four large pins for each of the 3-phases and neutral, and two small pins for the external power interlock circuit.

      (2) The external power access door activates a micro-switch that illuminates the EXT PWR light on the pilot's caution/warning/advisory panel when the external power door is open.

EXTERNAL POWER MONITOR LOCATION



09-93-48
83-156C

NOTES

4. External power monitor

a. Monitors the incoming external AC power for proper voltage level, frequency, and phase sequence.

b. Mounted in the aft avionics bay.

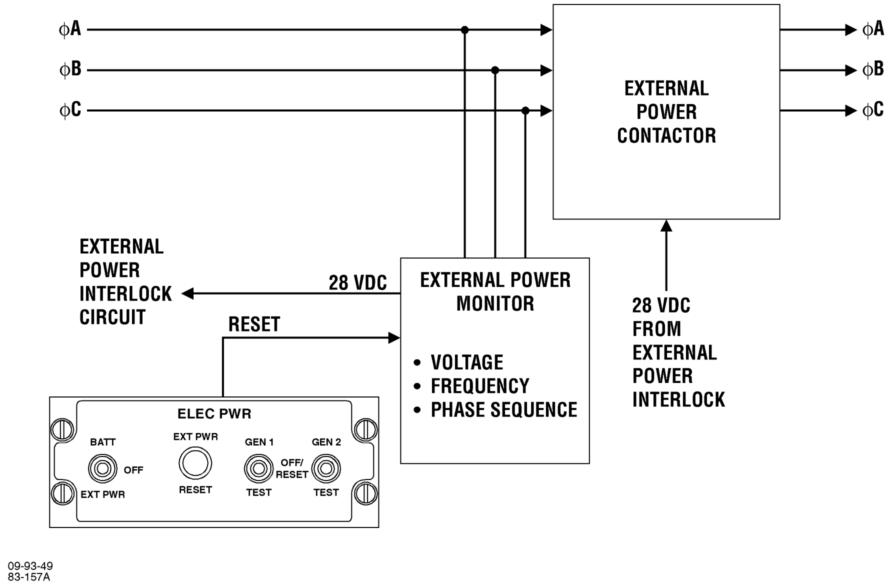
c. Description

(1) A solid-state LRU with one quick-disconnect receptacle.

(2) Rectifies the 3-phase, 115/200 VAC, 400 HZ from the external power source to provide interlock 28 VDC, at up to 5 amps of current capability (enough to energize the external power contactor).

(3) Prevents application of improper external power to the aircraft AC electrical power system.

EXTERNAL POWER MONITOR SIMPLIFIED FUNCTIONAL DIAGRAM



NOTES

d. External power monitor operation

(1) 3-phase, 115 VAC, 400 Hz power is applied to the external power monitor and the external power contactor from an external power source, via the external power receptacle.

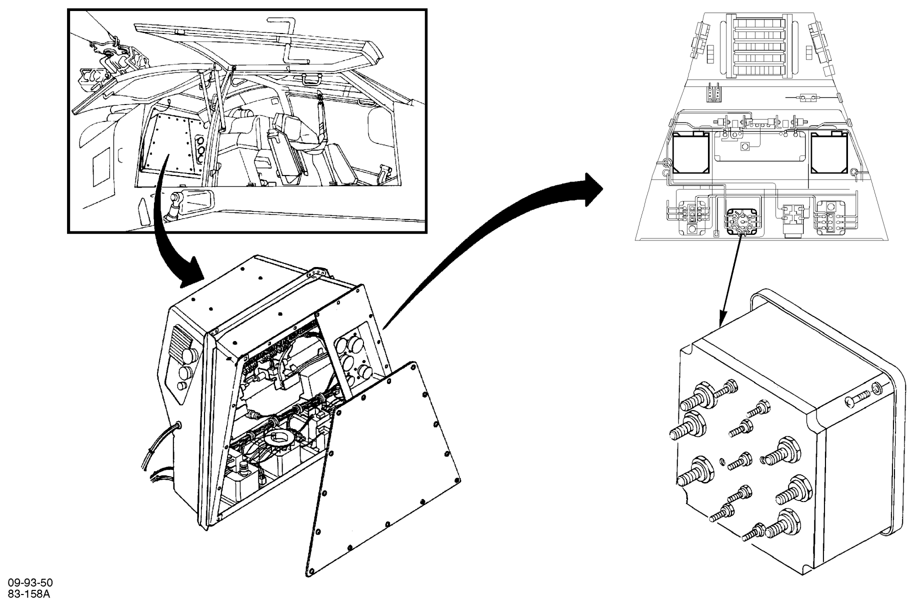
(2) The external power monitor checks this power for proper voltage, frequency, and phase sequence.

(3) If the power is within tolerance, the external power monitor develops the interlock 28 VDC and connects it to the external power interlock circuit.

(4) If the external power monitor detects improper voltage, frequency, or phase sequence, the interlock 28 VDC is interrupted electronically by the external power monitor circuitry.

(5) External power is locked out until the external power monitor fault sensing circuit is reset by the EXT PWR RESET, then the external power monitor checks input power again. If it is still out of tolerance, the system remains locked out. If it is within tolerance, the external power monitor will provide the interlock 28 VDC to the external power interlock circuit and allow external power operation to be regained.

EXTERNAL POWER CONTACTOR LOCATION



NOTES

5. External power contactor

a. Connects incoming power to the aircraft's AC electrical system.

b. Located in the electrical power distribution center, behind the pilot's seat.

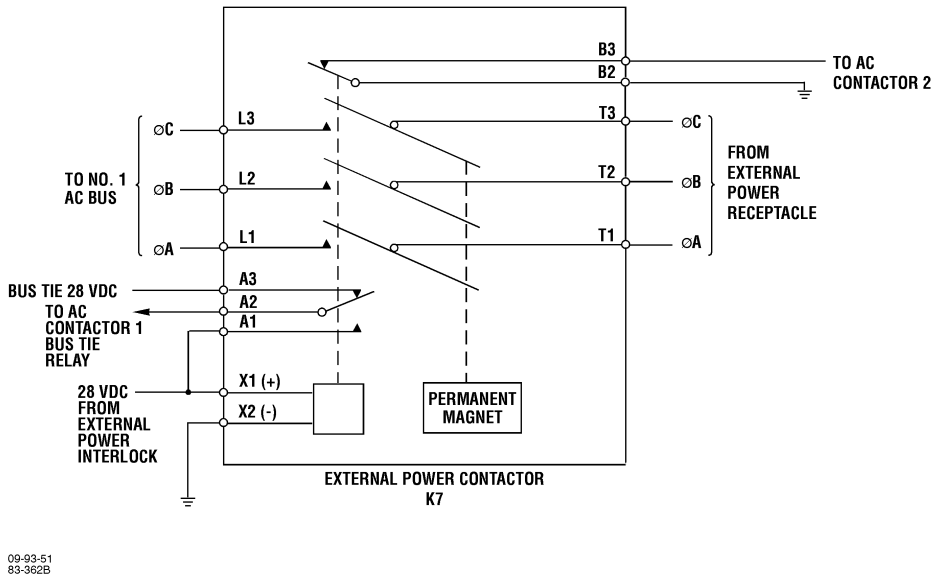
c. Description

(1) An LRU with 13 terminal studs on the front face, six high current and eight low current terminals.

(2) Energized by interlock 28 VDC from the external power monitor.

EXTERNAL POWER CONTACTOR SIMPLIFIED FUNCTIONAL DIAGRAM

(DE-ENERGIZED)



NOTES

6. External power contactor operation

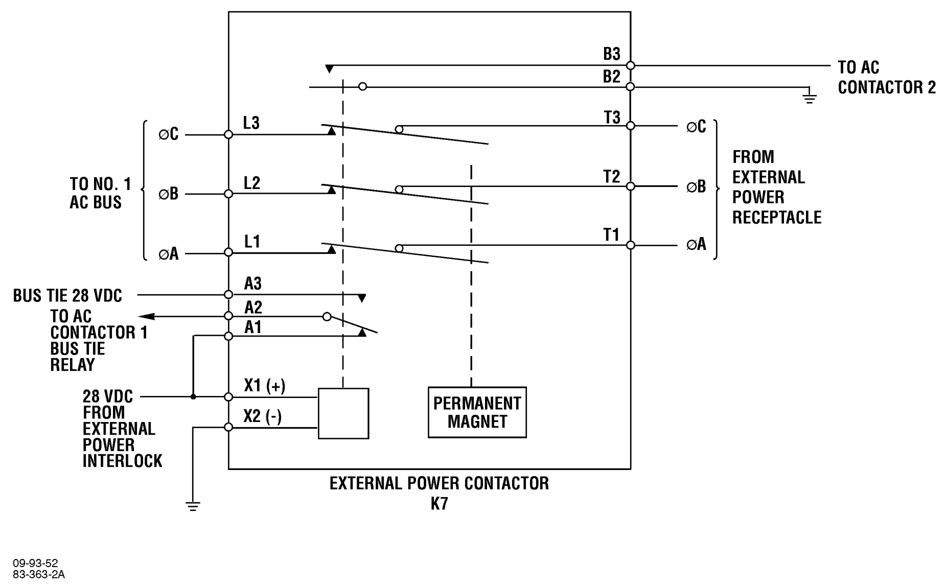
(1) No external power applied

(a) The external power contactor remains de-energized, contacts Ll, L2, and L3 are open by a permanent magnet, preventing application of external power to AC essential bus 1 and 2.

(b) The normally-closed contacts B2 and B3 of external power contactor connects a ground to the generator contactor relay 2 (coil A), which allows it to energize in normal AC system operation.

(c) The normally-closed contacts A2 and A3 connect RECTIFIED PMG 2 DC VOLTAGE (28 VDC) to bus tie relay (coil B) 1, allowing the No. 1 system to be powered by the No. 2 system if the AC generator 1 fails.

EXTERNAL POWER CONTACTOR SIMPLIFIED FUNCTIONAL DIAGRAM
(ENERGIZED)



NOTES

(2) External power applied

(a) When interlock 28 VDC is applied to the external power contactor relay, via the interlock circuit.

(b) The external power contactor energizes, applying 3-phase external power directly to the AC essential bus 1, via the closed high current terminals T1, T2, and T3, which are connected to terminals L1, L2, and L3 respectively.

(c) Closed contacts Al and A2 connect RECTIFIED PMG 2 DC VOLTAGE (28 VDC) to the bus tie relay 1 (coil B), which energizes and connects the AC essential buses 1 and 2 together.

(3) AC generator power applied

(a) With either generator on line, the respective generator contactor relay (coil A) is energized and opens the interlock 28 VDC power to the coil circuit of external power contactor preventing application of external power.

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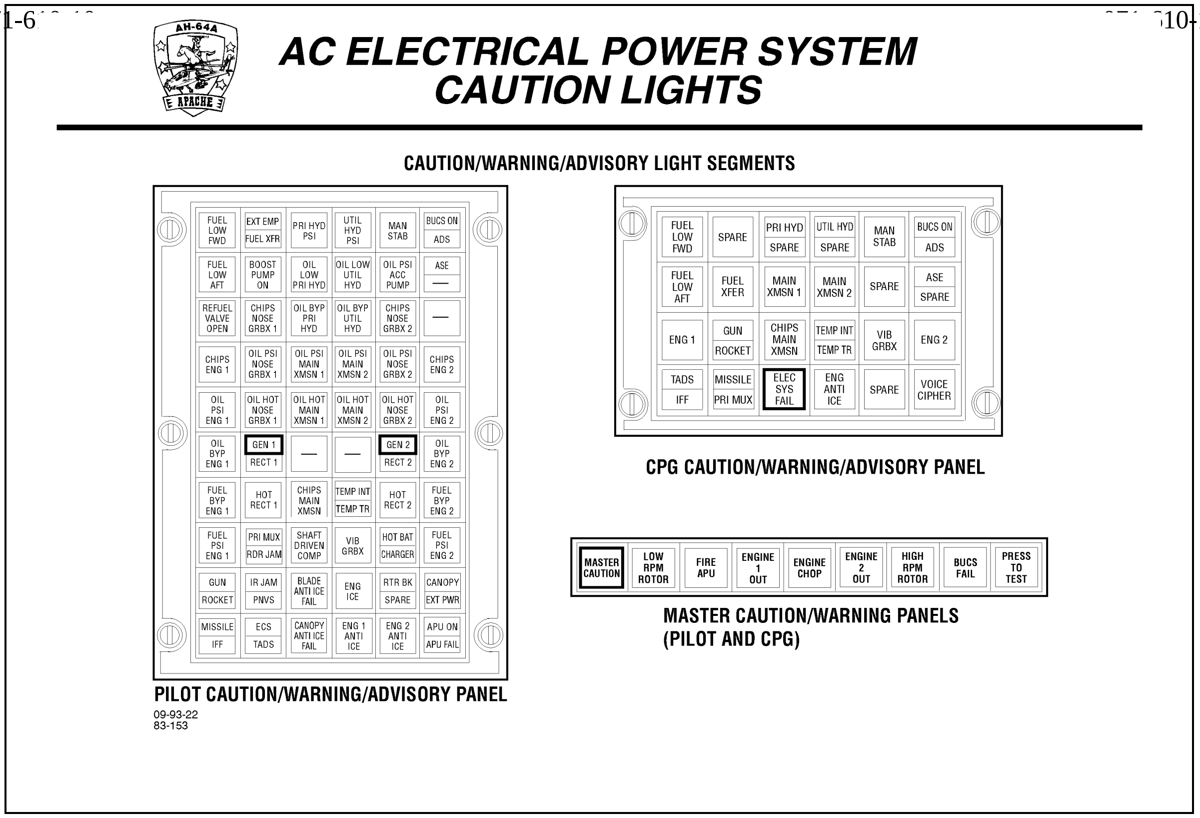


NOTES

7. EXT PWR caution light

   a. When illuminated, advises the pilot that the external power receptacle door is open.

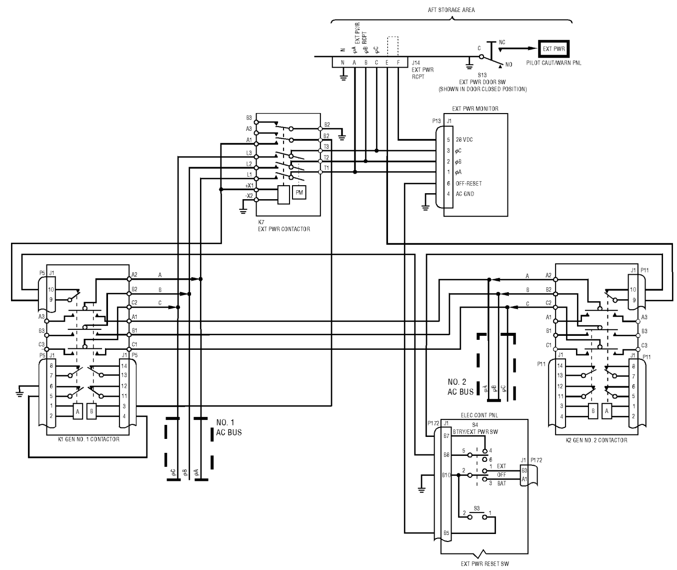
   b. Located on the pilot's caution/warning/advisory panel.

   c. Amber colored light segment

   d. The EXT PWR advisory light is controlled by a switch on the external power receptacle door.

071-610-10

EXTERNAL AC ELECTRICAL POWER APPLICATION



09-94-26

NOTES

A. External power normal operation

1. When external power from an approved ground power source is connected to the external power receptacle, 3-phase, 115 VAC, 400 Hz power is applied directly to the external power monitor and to the input terminals T1, T2, and T3 of the external power contactor. The external power contactor remains de-energized.

2. The external power monitor develops its internal supply voltages directly from the 115 VAC, 400 Hz external power input. With the 3-phase external power applied to the power monitor, it operates.

3. The external power monitor checks the incoming power for proper frequency, voltage, and phase sequence. If the incoming power is correct, the external power monitor develops the interlock voltage (interlock 28 VDC) from the AC input power.

4. The interlock 28 VDC is connected through the two small pins of the external power receptacle and the external power plug. The continuity of this external path ensures that the external power connector is properly seated in the receptacle.

   a. The plug must be connected correctly for the interlock to be completed at this point.

   b. Physical interruption will occur if the power cable is un-seated from the external power receptacle.

5. From the external power receptacle, the interlock 28 VDC is applied to AC generator contactor 2, generator contactor relay.

6. If the AC generator 2 is operating and is connected to the AC essential bus 2, the interlock path is interrupted by the energized generator contactor relay 2.

7. If the AC generator 2 is NOT OPERATING, the de-energized generator contactor relay 2 connects the interlock 28 VDC to the BATT/OFF/EXT PWR switch on the electrical power control panel in the pilot crewstation.

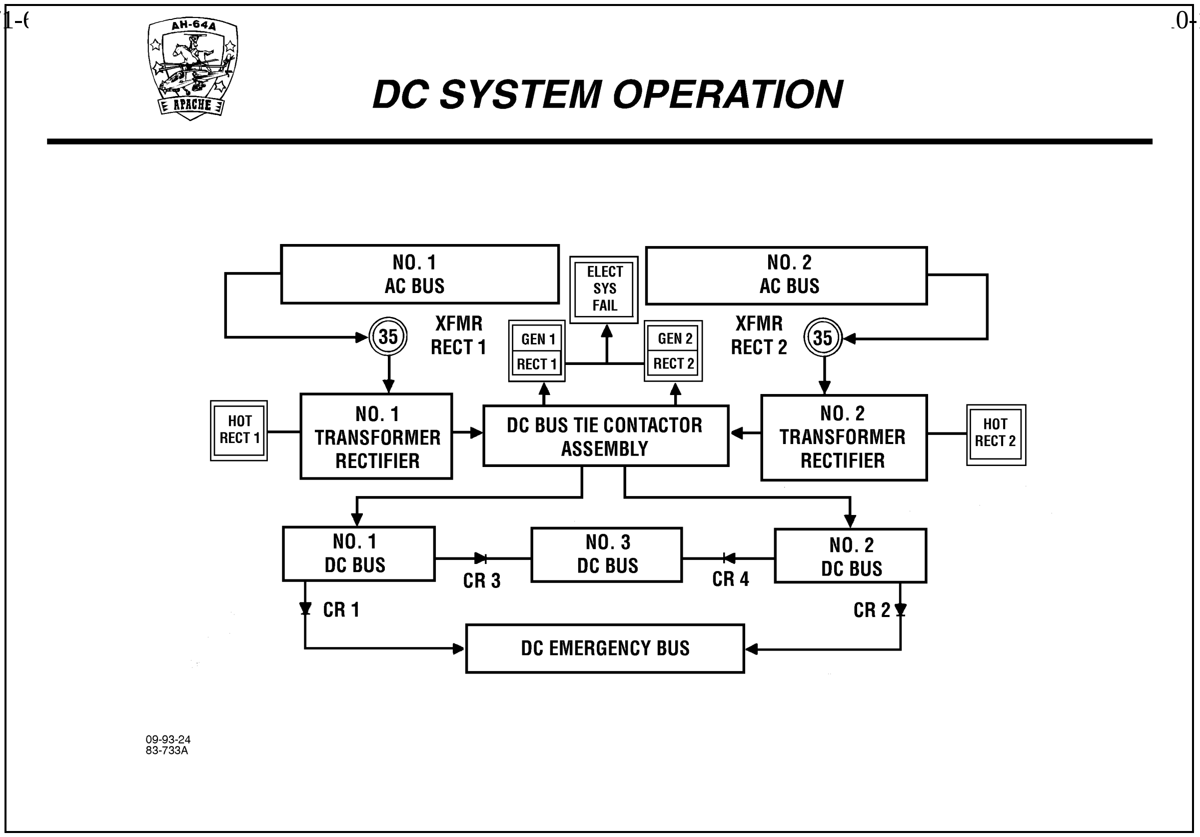
8. When the BATT/OFF/EXT PWR switch is placed in the EXT PWR position, the interlock circuit is completed to AC generator contactor, generator contactor relay 1 contacts.

9. If the AC generator 1 is operating and is connected to the AC essential bus 1, the interlock path is interrupted by the energized generator contactor relay 1.

10. If the AC generator 1 is NOT OPERATING, the de-energized generator contactor relay 2 connects the interlock 28 VDC to the coil of the external power contactor.

11. The external power contactor energizes, connecting 3-phase, 115 VAC, 400 Hz external power directly to the AC essential bus 1. The interlock 28 VDC is connected to the bus tie relay 1 (coil B) of the AC generator contactor 1, via the closed (A1, and A2) contacts of the external power contactor.

12. Bus tie relay 1 (coil B) energizes and connects the AC essential bus 1 to AC essential bus 2. External power is now connected to both AC essential bus 1 and 2.


DC SYSTEM OPERATION
NO. 1
AC BUS
ELECT
SYS
FAIL
NO. 2
AC BUS
35
XFMR
RECT 1
GEN 1
RECT 1
GEN 2
RECT 2
XFMR
RECT 2
35
HOT
RECT 1
NO. 1
TRANSFORMER
RECTIFIER
DC BUS TIE CONTACTOR
ASSEMBLY
NO. 2
TRANSFORMER
RECTIFIER
HOT
RECT 2
NO. 1
DC BUS
NO. 3
DC BUS
NO. 2
DC BUS
CR 3
CR 4
CR 1
CR 2
DC EMERGENCY BUS
09-93-24
83-733A

NOTES

A. DC electrical system

1. The DC electrical system provides two separate sources of 28 VDC power for the AH-64A systems that require DC power.

   a. DC system No. 1 converts the No. 1 AC essential buses 3-phase, 115/200 VAC, 400 Hz power (as supplied normally by the No. 1 AC generator) to produce a source of 28 VDC power to the DC power contactor.

   b. DC system No. 2 converts the No. 2 AC essential buses 3-phase, 115/200 VAC, 400 Hz power (as supplied normally by the No. 2 AC generator) to produce a source of 28 VDC power to the DC power contactor.

   c. Distributes the two sources of 28 VDC, via a DC power contactor, to DC essential buses 1 and 2. DC essential buses 1 and 2 provide bus power through four isolation diodes to DC essential bus 3, and the emergency DC bus.

B. Features and capabilities

1. The DC electrical power system consists of two functionally identical and redundant systems. Each system can provide up to 250 AMPS of current. Normally each system provides approximately half that amount.

C. Input power requirements

1. Under normal conditions, each DC electrical system converts one-eighth of the AC essential bus power into 28VDC at 80% efficiency. Using OHM's Law for power and converting for reduction in output power due to efficiency

$$P = I \times E$$

$$3.5 \text{ KVA output power} = 125 \text{ amps} \times 28 \text{ VDC}$$

$$\text{OUTPUT POWER} = \text{INPUT POWER} \times \text{EFFICIENCY}$$

$$3.5 \text{ KVA output power} = \text{input power} \times 80\%$$

$$3.5 \text{ KVA output power} = \text{input power} \times .80$$

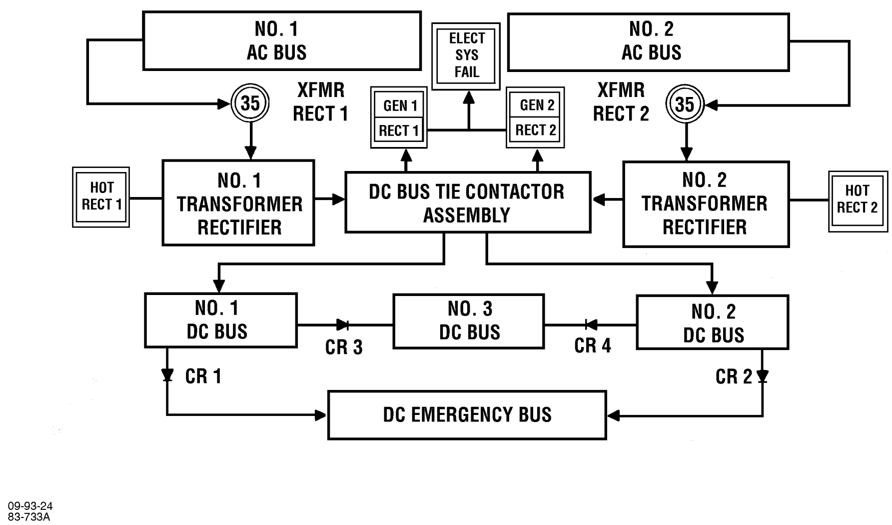
$$\frac{3.5 \text{ KVA output power}}{.80} = \text{input power}$$

$$4.375 \text{ KVA} = \text{input power}$$

   a. Under normal conditions EACH AC generator provides approximately 17.5 KVA of it's 35 KVA total power capability.

   b. From the 17.5 KVA, 4.375 KVA is used for conversion to DC power and the remaining 13.125 KVA is normally used by systems that use AC power directly.

DC SYSTEM OPERATION



NOTES

2. If an AC generator fails, the remaining AC generator will provide 3-phase, 115/200 VAC, 400 Hz power for conversion by both DC electrical systems and all the helicopter systems that use AC power directly.

2 x 4.375 = 8.75 KVA for both DC systems

2 x 13.125 = 26.25 KVA for both AC systems

8.75 KVA DC power requirements +

26.25 KVA AC power requirements =

35 KVA power that one AC generator can provide.

3. This allows one AC generator to supply all of the AC and DC power requirements of the helicopter.

D. Output power capabilities

1. Each DC electrical system normally supplies approximately 125 AMPS of current, or half of the DC power requirements for the helicopter.

2. Either system can supply all DC power requirements.

3. If either system malfunctions, automatic switching by the DC bus tie contactor ensures continued DC electrical operation.

E. Major electrical components

1. Transformer/rectifiers (T/R 1 and T/R 2)

2. DC bus tie contactor assembly

3. Bus isolation diodes

4. Caution/warning Lights

5. DC circuit breakers

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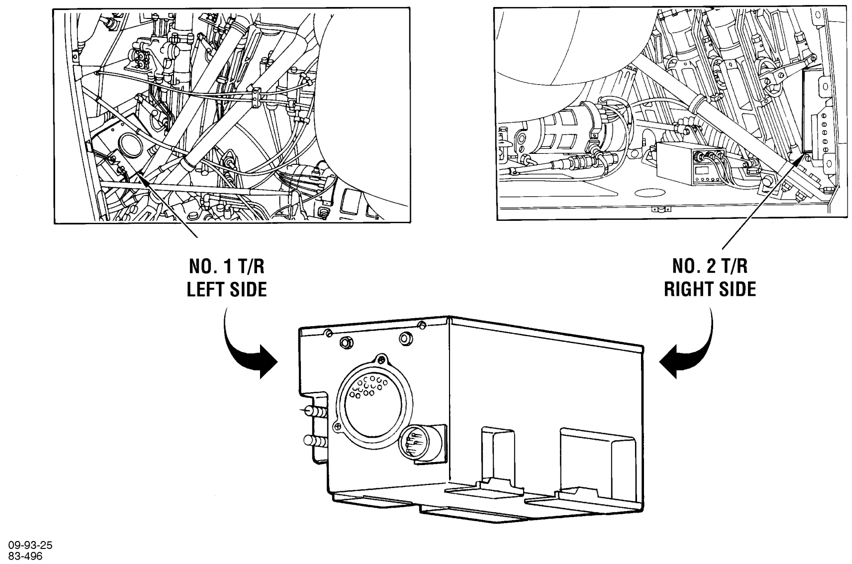
TRANSFORMER/RECTIFIER LOCATIONS



NOTES

F. T/R 1 and T/R 2

1. Purpose

a. Under normal operating conditions, T/R 1 and T/R 2 each convert their respective input, 3-phase, 115/200 VAC, 400 HZ AC essential bus power to provide approximately one-half (125 AMPS) of the 28 VDC power (250 AMPS) for the AH-64A DC powered systems.

b. If one T/R fails, the remaining T/R will provide all (250 AMPS) the 28 VDC to the DC powered systems.

c. The AC to DC conversion is accomplished by

(1) Transforming the 3-phase, 115 VAC, 400 Hz input to 3-phase, 28 VAC, 400 Hz.

(2) Full wave rectifying the 3-phase, 28 VAC, 400 Hz power to 28 VDC.

(3) Filters the 28 VDC to provide a smooth, rectified output for the DC powered system on the helicopter.

2. Location

a. T/R 1 is located on a canted mount, forward of the AC generator 1. The canted mount is attached to the forward deck area of the main transmission bay.

b. T/R 2 is mounted on the inside fuselage structure, immediately forward of access panel R260 in the main transmission bay.

3. Description

a. Compact LRU, weighing 22 pounds.

b. One quick-disconnect receptacle for input 3-phase, 115/200 VAC, 400 HZ power and control connections and two terminal studs for the high current 28 VDC output power connections to the DC bus tie contactor.

c. Provides its own forced-air cooling.

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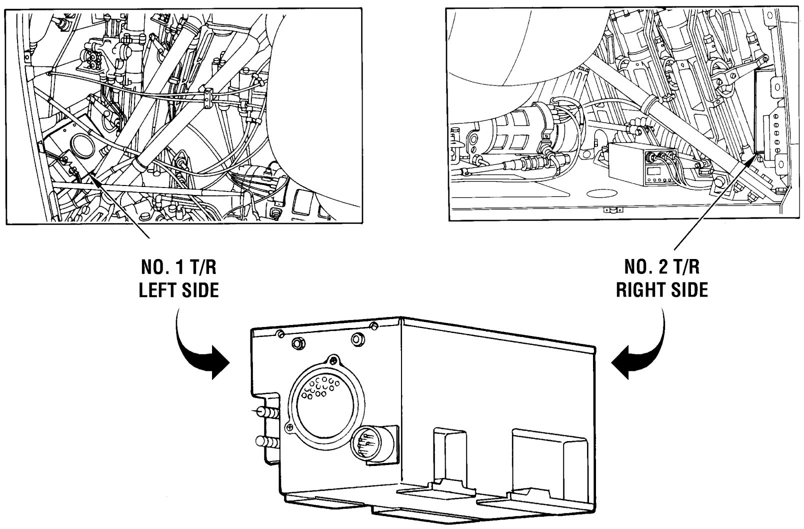
TRANSFORMER/RECTIFIER LOCATIONS



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NOTES

d. Each T/R consists of

(1) Three transformers

(2) One rectifier assembly containing 12 diodes

(3) Filter network

(4) Thermal sensor

(5) Fan motor

e. Each T/R can

(1) Provide 28 VDC at 250 amperes, continuously.

(2) Maintain output voltage limits of 25 to 29 VDC at loads of 25 to 250 amperes, respectively, throughout the allowable AC voltage range of the AC generators.

(3) Output 1000 amps for six seconds, 1400 amps for one second and 2000 amperes for 0.050 seconds.

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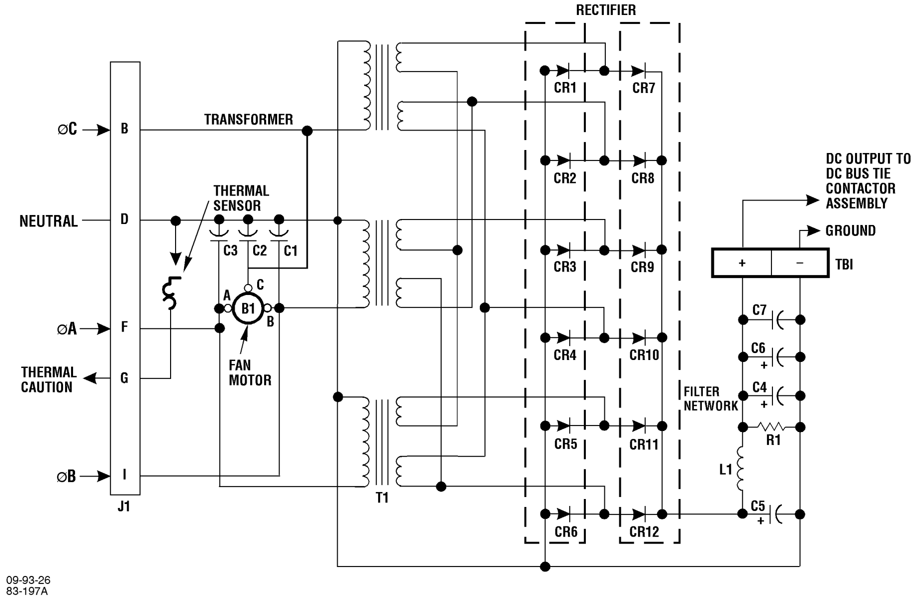
TRANSFORMER/RECTIFIER FUNCTIONAL SCHEMATIC



NOTES

G. Transformer/Rectifier Electrical operation

1. The AC essential bus phases A, B, and C, 115/200 VAC, 400 Hz are applied to J1, pins F, B and I, respectively. The AC neutral is applied to pin D.

2. Phases A, B, and C, are applied to the windings of the 3-phase, AC, T/R cooling fan motor, B1. The fan operates, providing cooling air for the T/R components. The fan motor is an essential component in the T/R, especially when the T/R is providing a high current output. Internal heat build up can cause severe damage to the T/R and disable it from providing the 28 VDC output.

3. In the event of an overtemperature condition, (normally due to failure of the cooling fan) the thermal sensor is activated.

4. The thermal sensor completes a circuit to illuminate the HOT RECT light on the pilot's caution/warning/advisory panel.

5. The three capacitors C1, C2 and C3, are connected to the input 3-phase voltages and form an radio frequency (RF) filter network which is used to reduce noise interference to the helicopter electronic systems.

6. Phases A, B, and C, 115/200 VAC, 400 Hz are also applied to the primary (input) of the respective phase winding of the "wye" (Y) configured, step-down transformers.

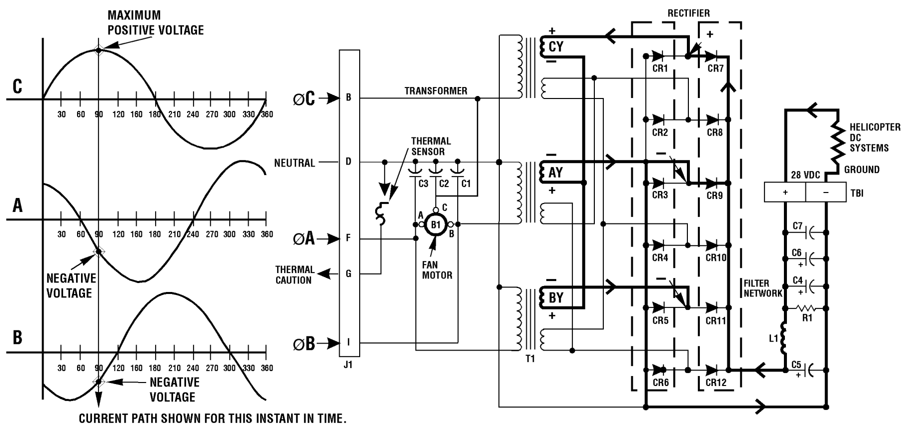
7. Through transformer action, each phase of the 115/200 VAC, 400 Hz from the individual primaries is inductively coupled to the "wye-delta" configured secondaries and the AC voltage level is "stepped down".

    a. The primary windings have more turns than the secondary windings. Due to transformer theory, the output voltage will be lower AND more current will flow in the "wye-delta" secondary windings for each phase. The transformer relationship that illustrates this fact is

    $$\frac{Np}{Ns} = \frac{Ep}{Es} = \frac{Is}{Ip} = \sqrt{\frac{Zp}{Zs}}$$

    b. The "wye-delta" winding configuration in the secondaries tends to maintain the output voltage level within reasonable limits over the wide current-range capability of the T/R. The "wye-delta" winding configurations tend to oppose each other in operation, one tends to maintain a constant current, the other tends to maintain constant voltage, the net result is the T/R's maintain output voltage limits of 25 to 29 VDC at loads of 25 to 250 amperes.

TRANSFORMER/RECTIFIER "WYE" WINDINGS CURRENT PATH



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NOTES

8. The AC voltages induced in the secondary windings are full wave rectified by silicon rectifier diodes CR1 through CR12.

9. During operation, current will flow through various combinations of the "wye-delta" secondary windings and rectifier diodes. The diodes that permit current flow though the individual windings depends on the amplitude and polarity of each phase's voltage AT A SPECIFIC INSTANT IN TIME. Positive voltage must be present on the ANODE and Negative voltage must be on the CATHODE for the rectifiers to conduct. One possible current path combination is

   a. At the time when phase C is at it's maximum Positive peak voltage. During this instant phase A and phase C are both slightly negative.

   b. The "wye" winding current paths are as follows

      (1) CR7 is forward biased by the Positive voltage from the phase C winding present at the junction of CR1's cathode and CR7's anode.

      (2) CR1 is back biased and will not conduct.Current will flow from ground through the load (any helicopter system that is operating at the time), to the cathode of CR7.

      (3) Current flows through CR7 and to the phase C winding.

      (4) Current will flow through the phase C winding, split and flow through the phase B and phase A windings to CR5 and CR3 respectively.

      (5) CR5 is forward biased by the Negative voltage, on it's cathode, from the Phase B winding present at the junction of CR5 and CR11. Ground appears positive to the diode and it conducts with negative voltage on the cathode and (positive) ground on the anode. CR11 is back biased and will not conduct.

      (6) CR3 is forward biased by the Negative voltage from the Phase A winding present at the junction of CR3 and CR9. Ground appears positive to the diode and it conducts with negative voltage on the cathode and (positive) ground on the anode. CR9 is back biased and will not conduct.

      (7) Current flows through the forward biased CR5 and CR3 and returns to ground.

      (8) The remaining diodes are back biased and will not conduct, providing no other current paths at this instant in time.

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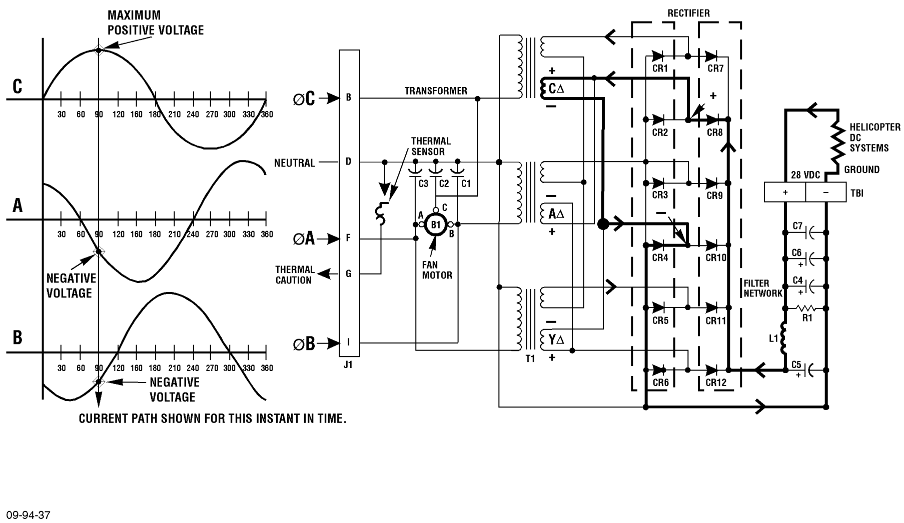
TRANSFORMER/RECTIFIER "DELTA" WINDINGS CURRENT PATH



NOTES

c. The "delta" winding current paths are as follows

(1) CR8 is forward biased by the Positive voltage from the phase C winding present at the junction of CR2's cathode and CR8's anode. CR2 is back biased and will not conduct.

(2) Current will flow from ground through the load (any helicopter system that is operating and using 28 VDC at the time), to the cathode of CR8.

(3) Current flows through CR8 and to the phase C winding.

(4) Current flows through the phase C winding, to CR4.

(5) CR4 is forward biased by the Negative voltage from the Phase C winding present at the junction of CR4 and CR10. Ground appears positive to the diode and it conducts with negative voltage on the cathode and (positive) ground on the anode. CR10 is back biased and will not conduct.

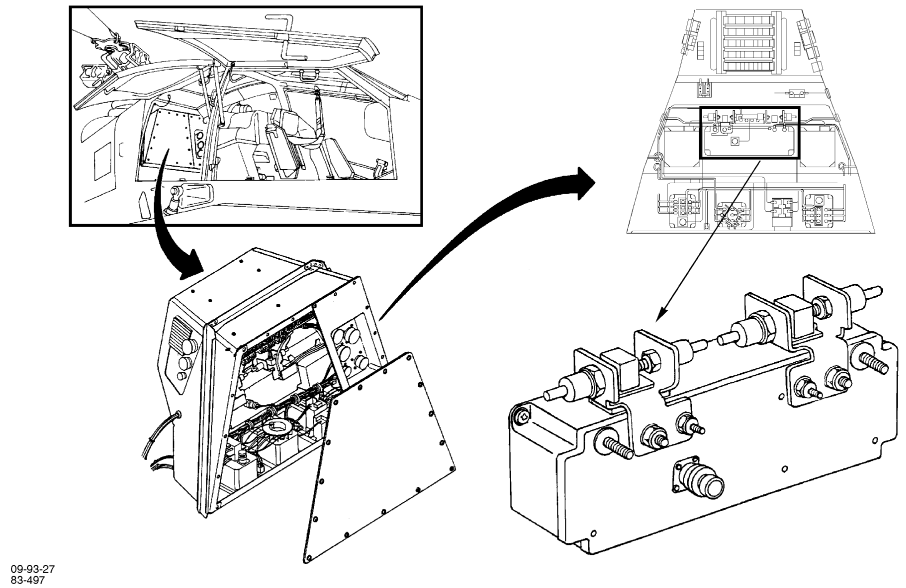
(6) Current flows through the forward biased CR4 and returns to ground.

(7) The remaining diodes are back biased and will not conduct, providing no other current paths at this instant in time.

10. This rectified voltage is filtered by a network consisting of capacitor C5, inductor L1, capacitors C4, C6, and C7. The network has a bleeder resistor, R1, to ensure discharge of the filter capacitors when the system is de-energized or disconnected.

11. This network prevents the ripple voltage from exceeding the limit of 1.5 volts, and reduces radio frequency noise.

DC BUS TIE CONTACTOR ASSEMBLY LOCATION



NOTES

H. DC bus tie contactor assembly

1. Connects the T/R output to the respective DC essential bus and provides the bus tie function in the event of a T/R failure.

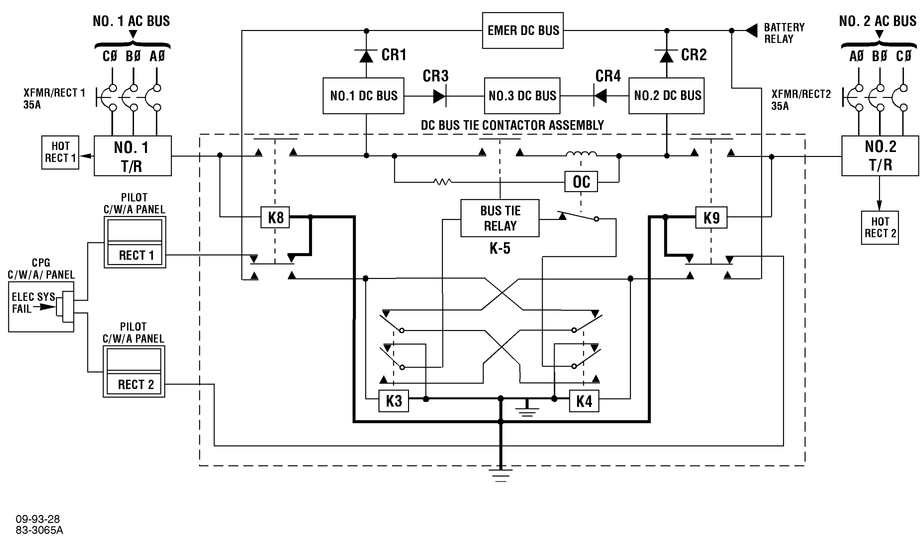
2. The contactor assembly is mounted in the electrical power distribution center, behind the pilot's seat.

3. Description

   a. Compact LRU, weighing 2 pounds.

   b. Has four terminal studs and one quick-disconnect receptacle for power and control connections.

DC BUS TIE CONTACTOR ASSEMBLY FUNCTIONAL DIAGRAM



NOTES

c. Consists of

(1) Two T/R contactors (K8 and K9)

(2) Two switching relays (K3 and K4)

(3) One bus tie relay (K5)

(4) Overcurrent sensor controlled relay

d. The DC bus tie contactor assembly can

(1) Connect the output of the T/Rs to the respective DC essential buses 1 and 2 and, via isolation diodes, DC essential bus 3 and the emergency DC bus.

(2) In the event of a failed T/R, connects power to the essential DC buses 1 and 2 from the remaining functioning T/R. The isolation diodes function as before.

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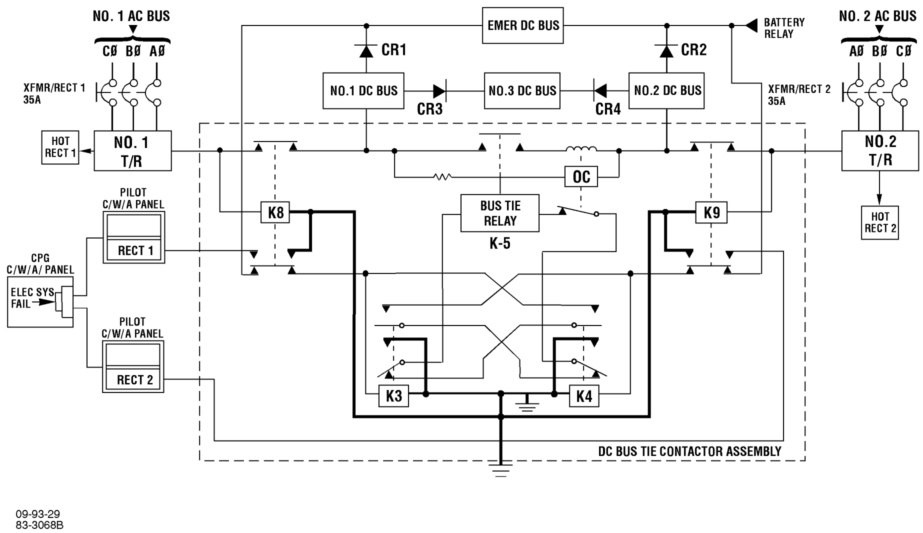
DC BUS TIE CONTACTOR ASSEMBLY NORMAL OPERATION



NOTES

I. DC Bus Tie Contactor Assembly Normal Operation

1. The 28 VDC outputs from T/Rs 1 and 2 energize the coils of the K8 and K9 contactors, respectively.

2. When K8 is energized

   a. T/R 1 is connected to the DC essential bus 1.

   b. RECT 1 caution light is extinguished.

3. When K9 is energized

   a. T/R 2 is connected to the DC essential bus 2.

   b. RECT 2 caution light is extinguished.

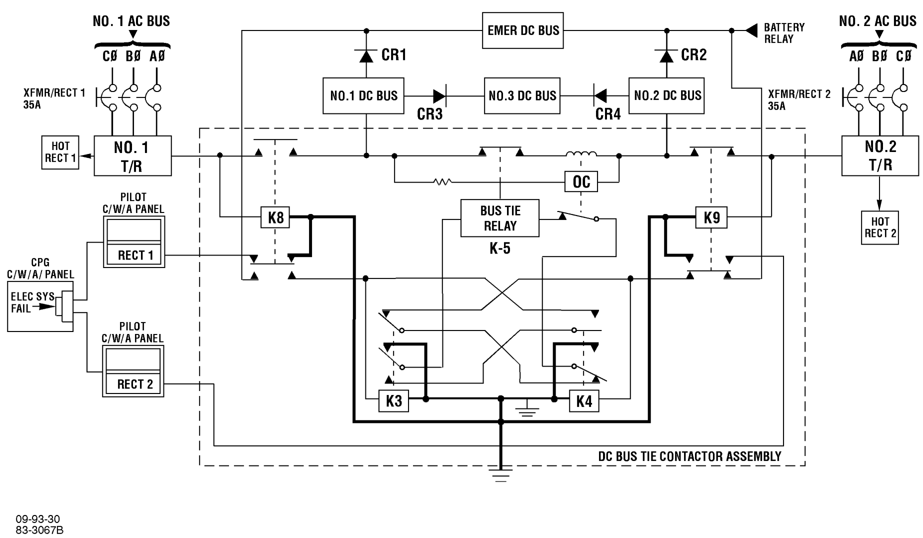
4. With both relays energized, the emergency DC system is connected to, and energizes, the coils of relays K3 and K4.

   a. When both K3 and K4 are energized, the circuit to the coil of the bus tie relay K5 is opened.

   b. Keeping K5 de-energized when both T/Rs are operating prevents parallel connection of the operating T/Rs.

5. A failed T/R causes the DC bus tie contactor to interconnect the DC essential buses, providing 28 VDC to all systems.

DC BUS TIE CONTACTOR ASSEMBLY
NO. 1 T/R INOPERATIVE



NOTES

6. If T/R 1 fails, voltage is lost to the coil of K8 and it de-energizes.

   a. K8's normally-closed contacts connects the ground to the RECT 1 caution light, illuminating the segment on the pilot's caution/warning/advisory panel.

   b. K8's normally-open contacts remove emergency DC bus voltage from the coil of K3 and K3 de-energizes.

   c. With K3 de-energized and K4 still energized, the normally-closed contacts of K3 connects emergency DC bus voltage to the coil of the bus tie relay (K5) via the normally-open contacts of K4, energizing K5.

   d. When K5 is energized, the DC essential bus 1 is connected to the DC essential bus 2 and receives power from T/R 2.

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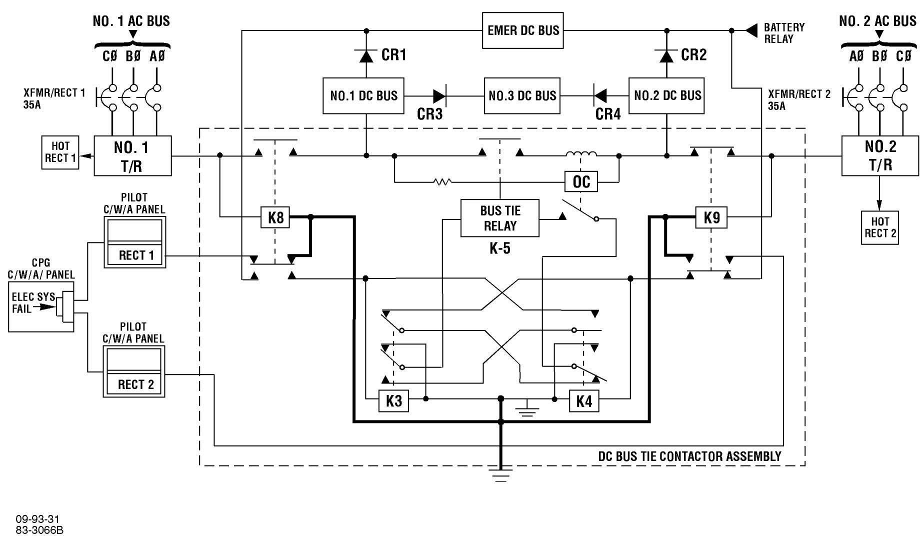
DC BUS TIE CONTACTOR ASSEMBLY NO. 1 T/R INOPERATIVE - OVERCURRENT CONDITION



NOTES

7. Overcurrent relay operation

a. Overcurrent protection is available when only one T/R is operating and the DC bus tie relay is energized.

b. When the bus tie relay is energized, DC essential bus 1 power is routed through the overcurrent (OC) relay OC sensing coil.

c. The normally-closed contacts of the OC relay are in series with coil K5 of the bus tie relay. The condition that can create an overcurrent is an approximate 0.1 ohm short to the ground of one DC essential buses, DC essential bus 1 in this case. If current flow through the bus tie circuit exceeds 300 "30 amps, the overcurrent relay sensing coil causes the relay to energize.

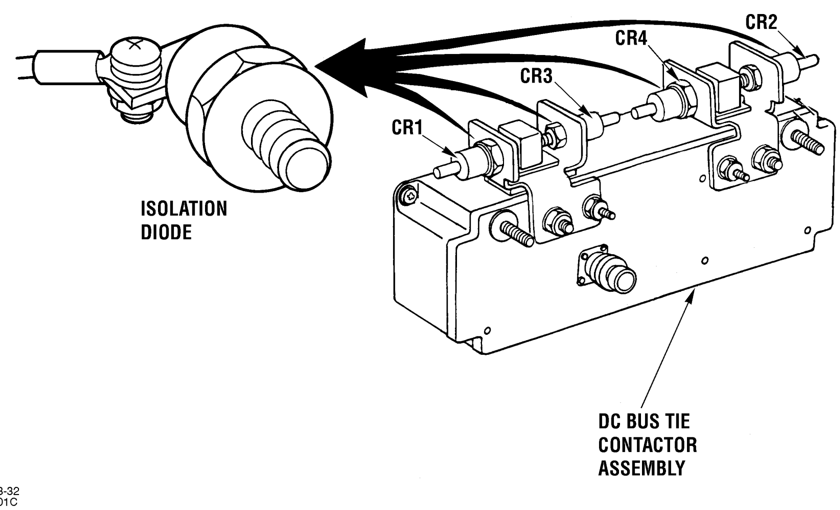
d. When the overcurrent relay energizes, the circuit to the coil of the bus tie relay is opened and it de-energizes, disconnecting the shorted DC essential bus 1 bus from the operating T/R.

e. The OC relay coil's latching coil energizes, keeping the OC relay energized.

(1) Since the OC relay coil's latching coil is connected across the DC essential buses 1 and 2, one end of the OC relay coil's latching coil is connected to ground (through the 0.1 ohm short to ground on DC essential bus 1) and the other end of the OC relay coil's latching coil is connected to 28 VDC of the DC essential bus 2. This causes the OC relay coil's latching coil to energize.

(2) The latching coil ensures that the OC relay remains energized, keeping the bus tie relay from being reconnected to the defective DC essential bus 1.

ISOLATION DIODES LOCATION



NOTES

J. Bus isolation diodes

1. Purpose

   a. CR1 connects the DC essential bus 1 to the emergency DC bus for normal operation. In the case of DC essential bus 1 failure, the reverse-biased CR1 prevents the emergency DC bus from supplying power to the failed DC essential bus 1.

   b. CR2 connects the DC essential bus 2 to the emergency DC bus for normal operation. In the case of DC essential bus 2 failure, the reverse-biased CR2 prevents the emergency DC bus from supplying the failed DC essential bus 2 with power.

   c. CR3 connects the DC essential bus 1 to the DC essential bus 3 for normal operation. In the case of a DC essential bus 1 failure, CR3 prevents the DC essential bus 3 from supplying the failed DC essential bus 1 with power.

   d. CR4 connects the DC essential bus 2 to the DC essential bus 3 for normal operation. In the case of DC essential bus 2 failure, CR 4 prevents the DC essential bus 3 from supplying the failed DC essential bus 2 with power.

2. CRl, CR2, CR3, and CR4 are attached to the DC essential buses on the DC bus tie contactor assembly.

3. The isolation diodes are heavy duty power diodes rated at 200 VDC at 150 amperes.

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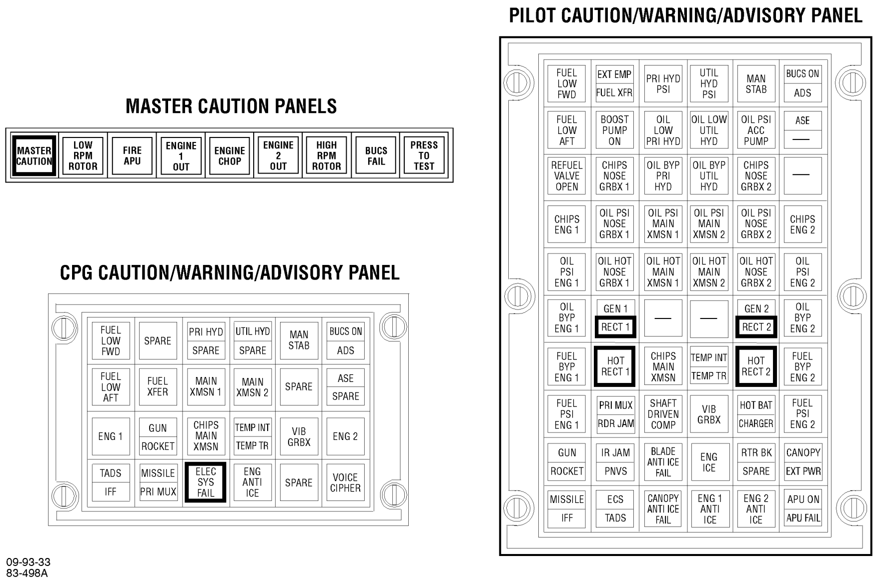
DC ELECTRICAL SYSTEM CAUTION LIGHTS



NOTES

K. Caution/warning lights

1. Master caution/warning light

    a. Advises the pilot and CPG that a caution/warning/advisory panel light has illuminated.

    b. Located on the master caution/warning panel in each crewstation.

    c. Is an amber-colored light that flashes when any caution/warning/advisory panel light illuminates.

2. ELEC SYS FAIL warning light

    a. Warns the CPG that both T/R's are unpowered.

    b. Is mounted on the CPG's caution/warning/advisory panel.

    c. Is a red-colored light segment that illuminates when both T/R's are not powered.

3. RECT 1 and RECT 2 caution light

    a. Advises pilot that the respective T/R has malfunctioned or is not connected to its respective DC essential bus.

    b. Is mounted on the Pilot's caution/warning/advisory panel.

    c. Is an amber-colored light segment that illuminates when the T/R has no output.

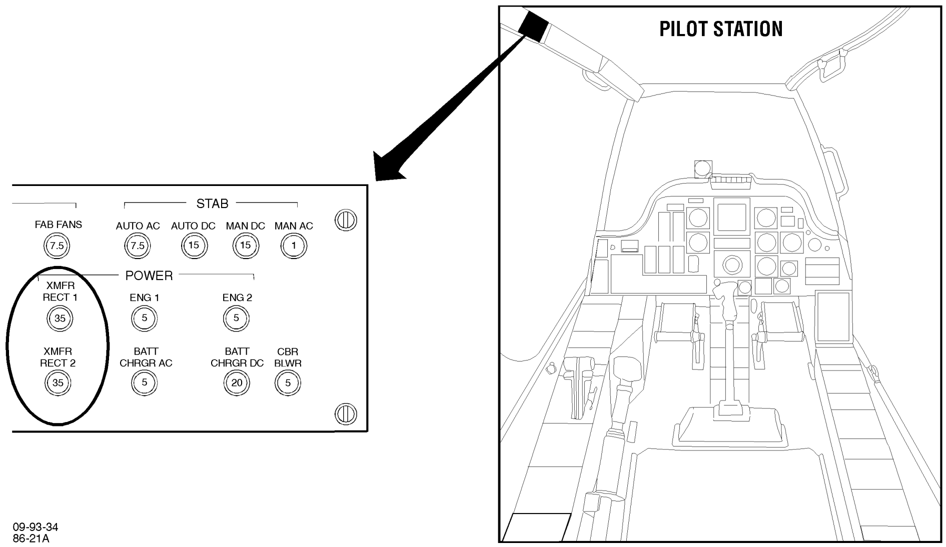
4. HOT RECT 1 and HOT RECT 2 caution light

    a. Advises the pilot that the respective T/R has overheated. This is an indication of impending failure only. The T/R will continue to operate until it fails.

    b. Is mounted on the pilot's caution/warning/advisory panel.

    c. Is an amber-colored light segment that illuminates when the internal temperature of the T/R reaches 190EF.

DC ELECTRICAL POWER SYSTEM XFMR RECT 1 & 2 CIRCUIT BREAKERS



NOTES

L. DC system circuit breakers

1. Provide thermal circuit breaker protection for the AC essential buses 1 and 2.

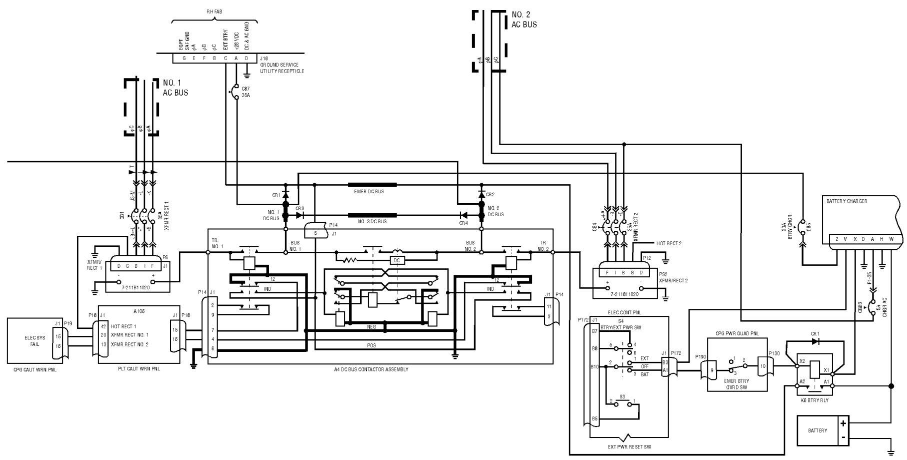
2. Located on the pilot's aft overhead circuit breaker panel.

3. Description

    a. Ganged, 3-phase, 115 VAC, 35 ampere circuit breakers.

    b. XFMR RECT 1 and XFMR RECT 2 supply 3-phase, 115 VAC, 400 Hz AC essential bus 1 and AC essential bus 2 power for T/R 1 and T/R 2 operation.

DC ELECTRICAL SYSTEM SCHEMATIC



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NOTES

A. DC electrical system normal operation

1. During normal operation, the AC essential bus 3-phase, 115/200 VAC, 400 Hz inputs are applied to 3-phase, 35 amp, ganged, XMFR RECT 1 (2).

2. The AC essential bus 1 supplies 3-phase, 115/200 VAC, 400 Hz power to T/R 1.

3. The AC essential bus 2 supplies 3-phase, 115/200 VAC, 400 Hz power to T/R 2 and the ground service receptacle.

4. Each T/R transforms and rectifies the respective 3-phase, 115/200 VAC, 400 Hz power to 28 VDC and supplies it to the DC bus tie contactor assembly.

5. The DC bus tie contactor assembly connects each T/R 28 VDC output to the respective DC essential bus.

6. The DC essential bus 1 supplies 28 VDC to the

    a. DC essential bus 1 loads

    b. DC bus 3 CR3

    c. Emergency DC bus through CR1

    d. Battery charger

    e. Ground service utility receptacle

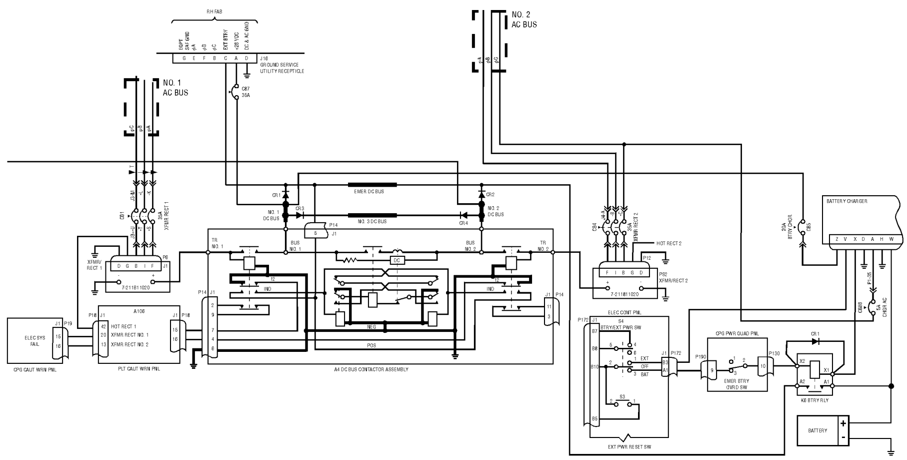
7. The DC essential bus 2 supplies 28 VDC to the

    a. DC essential bus 2 loads

    b. DC bus 3 through CR 4

    c. Emergency DC bus through CR2

DC ELECTRICAL SYSTEM SCHEMATIC



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NOTES

B. Malfunctions of the DC electrical system

1. T/R 1 total failure

    a. K9 connects a ground to the pilot's caution/warning/advisory panel, illuminating the RECT 2 caution light.

    b. K9 disconnects the T/R 2 output from the DC essential bus 2.

    c. K5 connects the DC essential bus 2 to the DC essential bus 1.

    d. The OC relay sensing coil monitors and ensures DC essential bus 2 current requirements do not exceed 300 " 30 amps.

2. T/R 1 partial failure

    a. If one of the three transformers fail in T/R 1, the remaining two continue to put out 28 VAC to the rectifier assembly. If the current demands on the DC essential bus 1 are small, the voltage output of T/R 1 may not have ripple voltage low enough to cause K8 to de-energize and perform DC bus tie operation. Normal or high current demands will de-energize K8. The increased ripple voltage degrades the operation of electronic equipment powered by the bus.

    b. The failure of one or more of the 12 diodes in the full wave rectifier assembly produce the same as the loss of a phase transformer in the example above.

    c. The failure of one or more components in the output filter network either increase ripples or interrupts the output.

    d. Failure of the fan or fan input power will causing the T/R to overheat and fail, illuminating the HOT RECT 1 light.

    e. Thermal sensor failure eliminates any advance warning of complete T/R failure or can turn on the HOT RECT 1 light erroneously.

3. DC bus tie failure

    a. Over Current Relay Failures

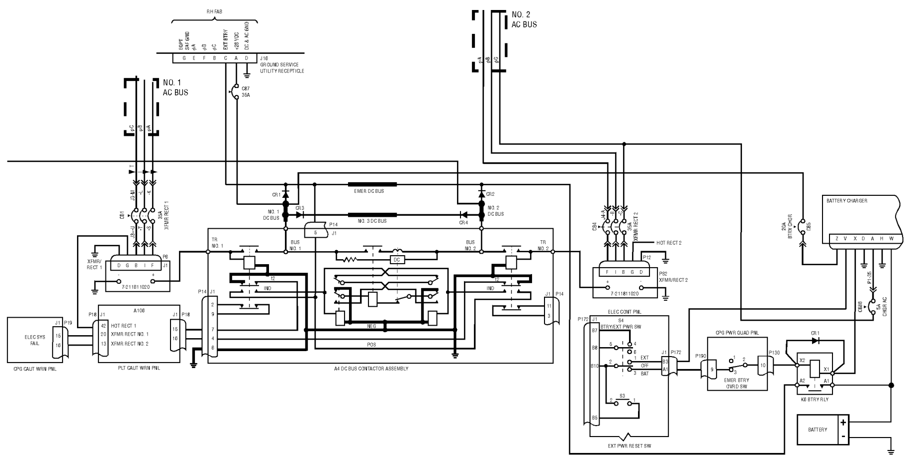
        (1) Failure of the OC sensing coil or contact pair(s) causes

            (a) A shorted bus to short out the remaining system.

            (b) The series path of DC essential bus 1 to DC essential bus 2 to open and interrupt bus tie operation.

071-610-10

DC ELECTRICAL SYSTEM SCHEMATIC



09-94-29

NOTES

(c) Cause the OC relay to be continuously energized or unable to energize. This prevents the bus tie from operating or leaves the bus tie operation unprotected from overcurrent.

(2) Failure of the latching coil

(a) Allows the OC relay to close immediately after opening.

(b) This short to ground of 28 VDC supplied by T/R 2 repeatedly draws excessive high current from T/R 2, and failure is expected.

(c) The output of T/R 1 falls below the low voltage output specification and DC powered systems have degraded performance if operational.

b. Failure of K8 coil or contact pair(s) latches up

(1) K3 causing the bus tie relay to lock in the open or closed position.

(2) The GEN caution/warning light.

(3) Connecting T/R 1 to DC essential bus 1.

c. Failure of K9 exhibits the same symptoms as K8 with respect to T/R 2 and DC essential bus 2.

d. Failure of K3 coil or contact pair(s) latches up operation of the bus tie contactor.

(1) Coil failure activates the bus tie relay.

(2) A non-functioning contact (welded closed or contaminated) latches the bus tie on or prevents bus tie activation.

e. Failure of K4 duplicates K3 failure.

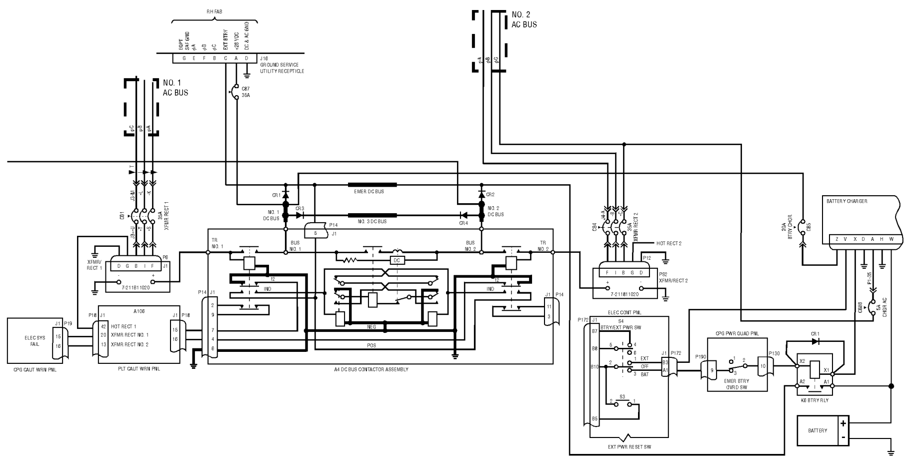
f. Failure of K5 interrupts the bus tie operation.

4. Isolation diode failures

a. There are two failure modes

(1) Short - this connects the DC essential bus 3 or the emergency DC bus through the shorted diode to either DC essential bus 1 or 2 without a provision for isolation. A short in either of the non-isolated buses eliminates the DC essential bus 3 or emergency DC bus and loads the remaining diode to the point of failure. The current rating of the isolation diodes is less than the T/R is capable of producing.

DC ELECTRICAL SYSTEM SCHEMATIC



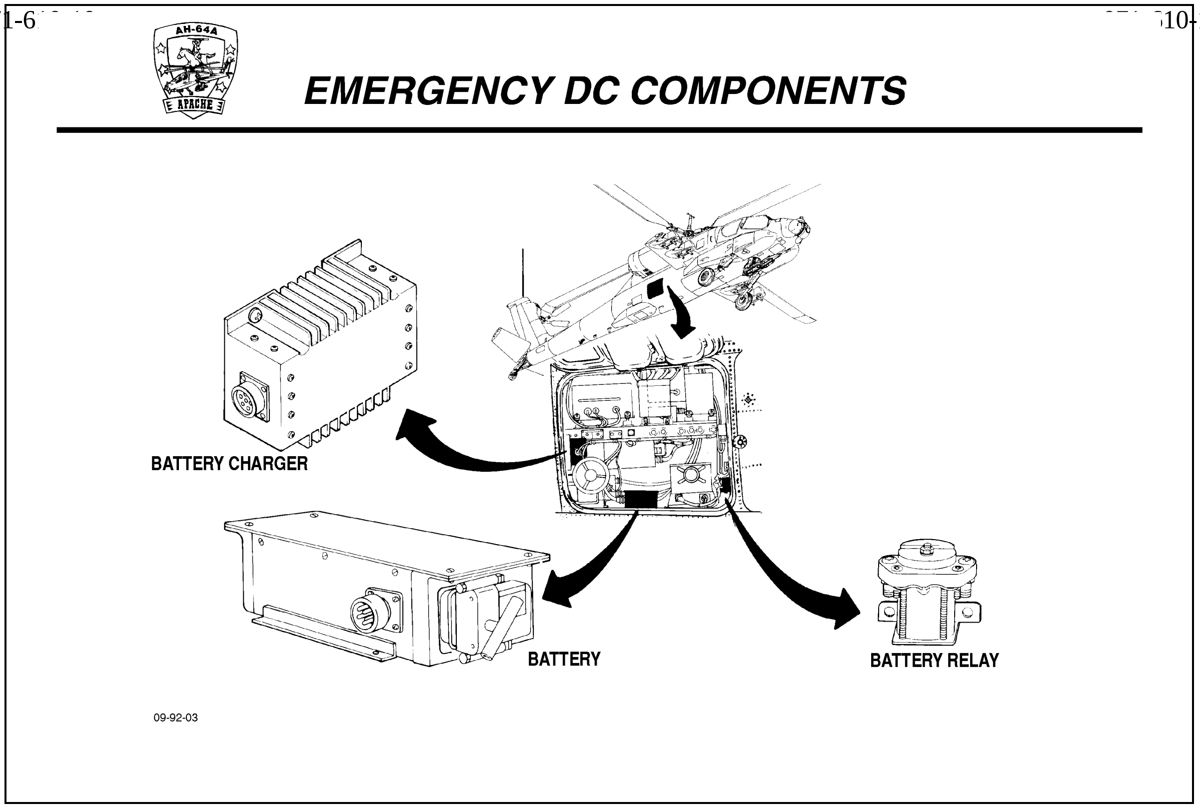
09-94-29

NOTES

(2) Open - this eliminates one redundant source of power to the critical bus.

5. DC circuit breaker failures - interruption of part or all of any system power source causes system degradation or system failure.

6. Caution/warning/advisory light failure - the loss of system status information degrades the information used for decision making.


EMERGENCY DC COMPONENTS
BATTERY CHARGER
BATTERY
BATTERY RELAY
09-92-03

NOTES

A. Emergency DC electrical system

   1. Provides the helicopter with an emergency power source in the event of complete electrical power system failure.

B. Features an emergency 24 VDC Ni-Cad battery with a support and control system.

   1. A battery charger to maintain the battery in a fully-charged state when not in use.

   2. A battery relay to connect the battery to the emergency DC bus. It is selected/de-selected by the crewmembers and activated by the battery charger control circuitry.

   3. Directly-connected circuit breakers to provide

      a. Work light power and target acquisition and designation sight/pilot's night vision sensor (TADS/PNVS) brake de-activation for maintenance.

      b. Power for fueling/de-fueling operations.

      c. Control of APU operation.

   4. Provides DC power for essential aircraft DC systems such as search light, intercommunications, radios, fuel system, rotor brake, emergency hydraulics, caution/warning/advisory panels, chaff, utility lights, radar altimeter, radar warning, pitot heater, and jettison.

C. Major components

   1. Battery

   2. Battery charger

   3. BATT/OFF/EXT PWR switch

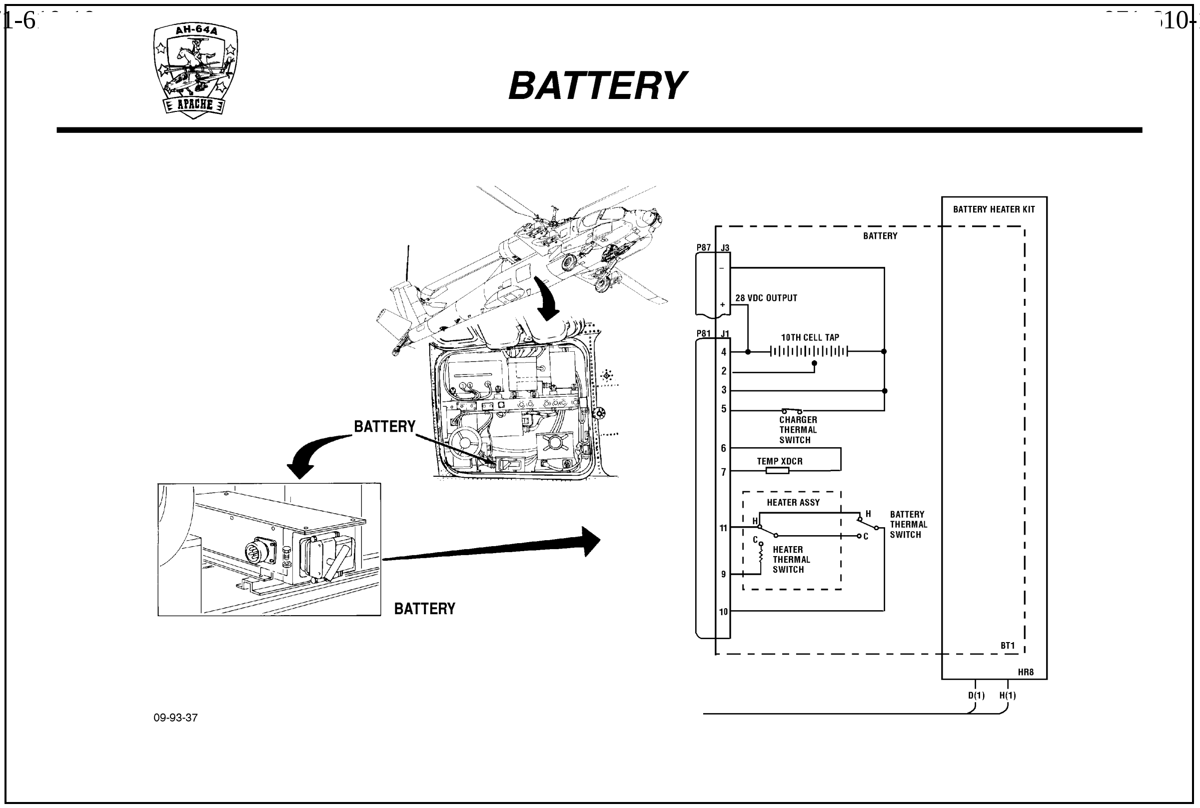
   4. CPG BATT OVRD switch

   5. Battery relay

   6. Caution lights

   7. Circuit breakers

071-610-10



NOTES

D. Battery

1. Supplies 24 VDC for APU start, and for emergency operation with a DC essential bus 1 and 2 failure.

2. Is mounted in the aft avionics bay.

3. Description

   a. Compact, lightweight (24 pounds), nickel-cadmium (ni-cad) battery with two connector receptacle.

      (1) A quick-connect, high-current, two-wire connector for power to the emergency bus.

      (2) A nine pin connector for control connection to the battery charger.

   b. NI-CAD batteries derive their name from the composition of their plates; nickel oxide of the positive and metallic cadmium of the negative.

   c. Contains 19 individual removable cells (1.25 volts per cell). They are connected in series by 1.50 by 0.50 inch metal links with a tenth cell tap for voltage imbalance sensing.

   d. Has an internal heater assembly to increase battery output capability in low ambient temperature conditions.

      (1) ON when battery cell temperature decreases to -5°C (23°F).

      (2) OFF when cell temperature rises above 0°C "5°C (32° "9°F).

   e. Has a temperature transducer to provide battery temperature information to the battery charger.

   f. Heater assembly and battery (cell-link) thermal switches for heater control.

      (1) The heater assembly is located next to the AC heater assembly and monitors its temperature. The switch is in the

         (a) Cold position below 105°"5°C (220°"9°F).

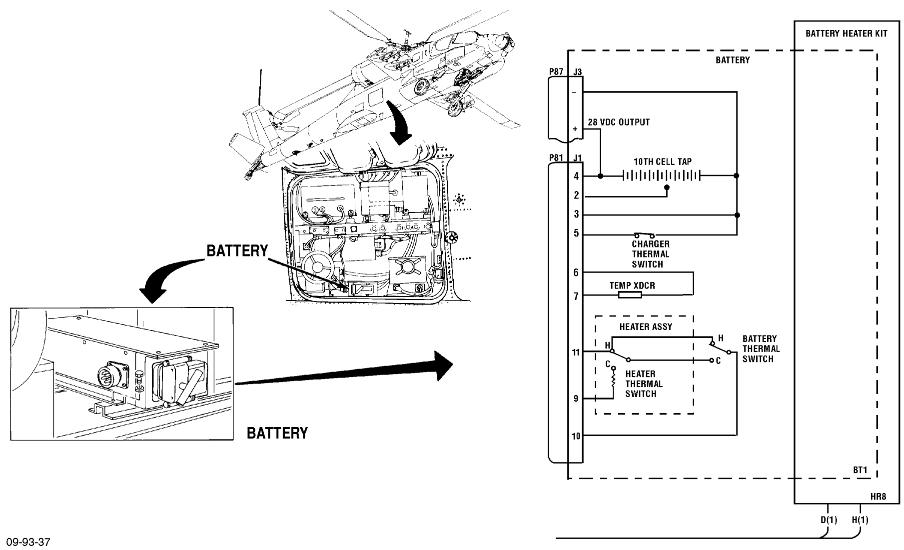
         (b) Hot position above 110°C (230°F).

      (2) The battery (cell-link) thermal switch is mounted on a battery cell connecting link and monitors the temperature of the link. The switches are in

         (a) Cold position below -5° (23°F).

         (b) Hot position above 0°"5°C (32°"9°).

BATTERY



NOTES

g. The battery can supply

(1) 24 VDC, 13 ampere-hour load for 60 minutes.

(2) 24 VDC, 75 ampere-hour load for 5 minutes.

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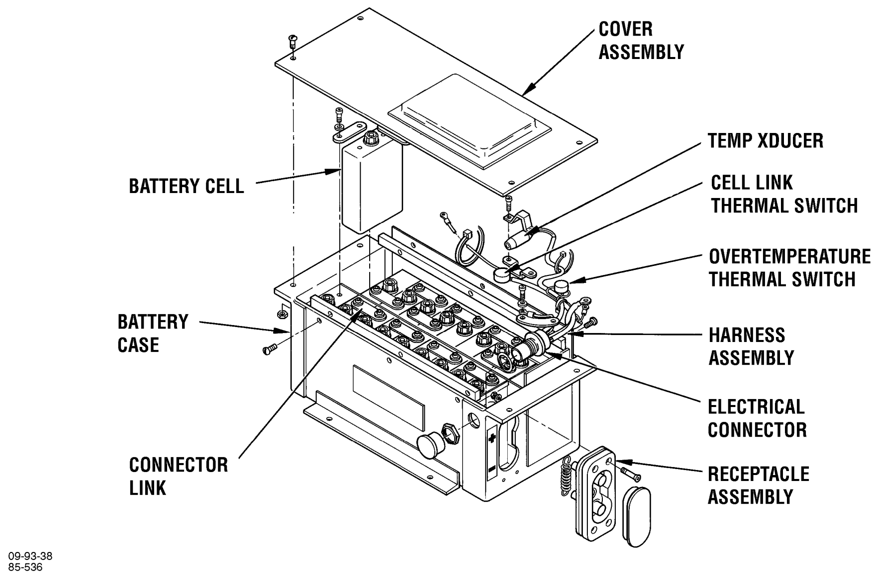
NI-CAD BATTERY ASSEMBLY



NOTES

4. Ni-Cad Battery Assembly

a. Battery case

(1) Provides containment and protection of the battery cells.

(2) Is a housing for the individual cells and components that make up the battery.

b. Battery cell

(1) Provides the electrical power that makes up the battery.

(2) An 1" x 3" x 5" container filled with an electrolytic solution which chemically produces the electrical power used in the Apache.

c. Cover Assembly

(1) Provides environmental protection.

(2) Encloses the contents that make up the battery. Prevents external contamination from entering the battery cells and prevents any cell electrolyte spillage from getting out.

d. Temperature Transducer

(1) Monitors the internal battery case temperature.

(2) A temperature sensing device mounted inside the battery case to monitor the ambient air temperature which is used by the heater control.

e. Heater Thermal Switch is Part of heater Assembly and is not showing:

(1) The heater thermal switch is located next to, and monitors the temperature of, the AC heater assembly. Heater assembly is used for thermal control of the battery cells to increase battery output capability in low ambient temperature conditions.

(2) Description

(a) In cold position below 105E " 5EC (220E "9EF).

(b) In hot position above 110EC (230EF).

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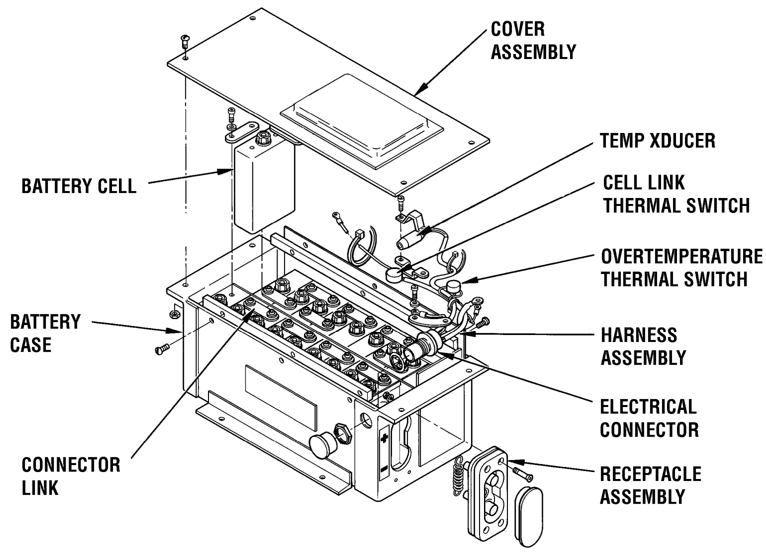
NI-CAD BATTERY ASSEMBLY



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85-536

NOTES

f. Battery (or Cell Link) Thermal Switch

(1) The battery thermal switch is mounted on a battery cell connecting link and monitors the temperature of the liner for heater control. The switch will be

(a) ON when battery cell temperature decreases (cold position) below -5EC (23E F).

(b) OFF when cell temperature rises (hot position) above 0E +5EC (32E "9EF).

(c) Mounted on battery cell connecting link.

g. Charger (or Battery Overtemperature) Thermal Switch

(1) Completes a circuit to the battery charger which illuminates the HOT BAT light on the pilot's caution/warning panel if the battery overheats.

(2) Description

(a) Closed above 57E "3EC (135E"5EF).

(b) Normally open below 49E "3EC (120E "5EF).

(c) Mounted on battery cell connecting link.

h. Harness assembly

(1) Provides interconnect between the internal cell thermal devices and external battery monitoring.

(2) Harness assembly made up of

(a) Temperature transducer (TEMP XDUCER):

1) Provides battery temperature information to the battery charger.

2) Electrical connector: contains 23 pins that are used for charging control and fault sensing.

i. Electrical Connector

(1) Provides electrical circuit connection for sensor outputs and power inputs through the battery case.

(2) 13 pin, bayonet-lock environmental, feed-through connector.

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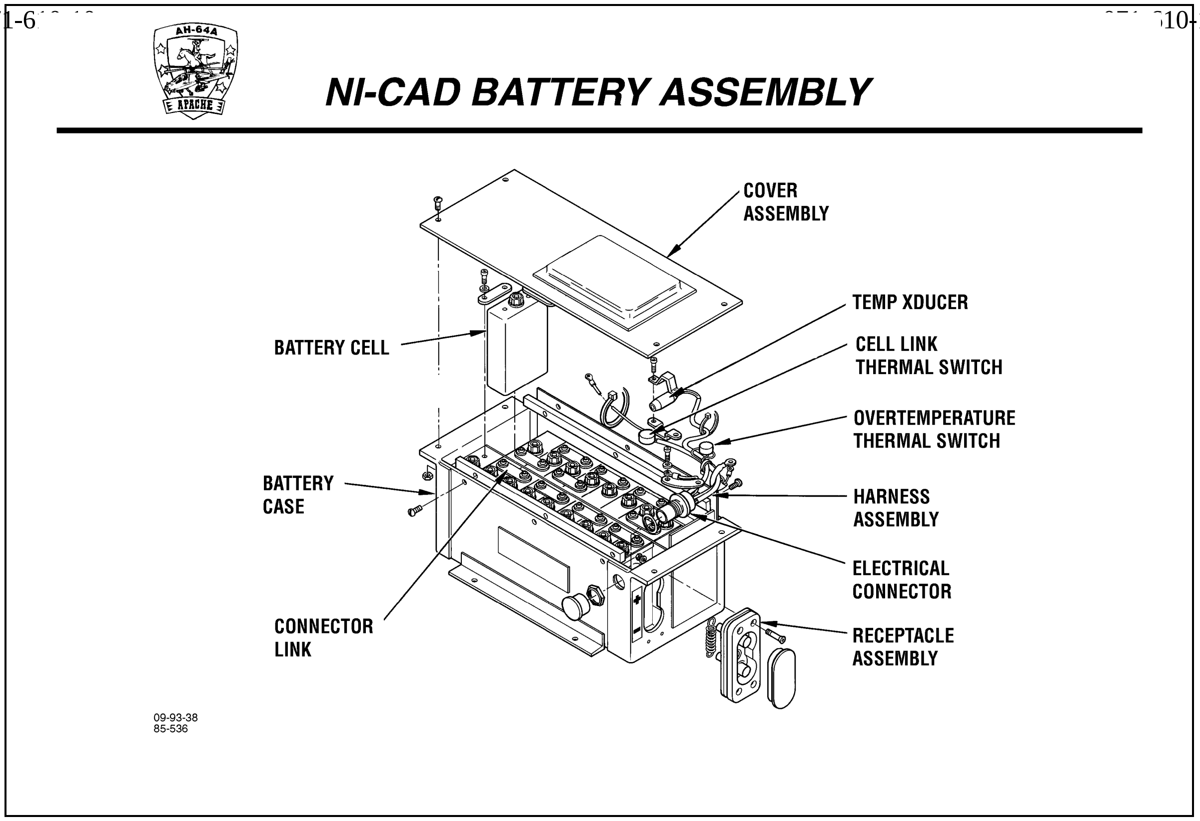


NOTES

j. Receptacle Assembly

(1) Battery output quick-disconnect connector.

(2) Connects the battery 24 VDC power output to the helicopter DC emergency bus system.

k. Connector Link

(1) Provides interconnection for the battery cells.

(2) A small metal strap which is used to interconnect the cell of the battery and also provides a secondary mount support.

NI-CAD BATTERY CHARACTERISTICS

- MAINTAINS STEADY VOLTAGE WHEN BEING DISCHARGED AT HIGH CURRENTS
- CAN BE CHARGED AND DISCHARGED AT A HIGH CURRENT RATE WITHOUT CAUSING PERMANENT DAMAGE
- CAN BE STORED IN ANY STATE OF CHARGE (FULLY CHARGED, PARTIALLY CHARGED, OR DISCHARGED) WITHOUT ANY DAMAGE
- CAN WITHSTAND EXTREMELY COLD TEMPERATURES WITHOUT DAMAGE
- CAN WITHSTAND HIGH LEVELS OF VIBRATION AND SHOCK WITHOUT FAILURE
- COMPOSED OF INDIVIDUALLY REPLACEABLE CELLS

85-537

NOTES

5. Ni-cad battery characteristics/advantages over lead-acid.

   a. Maintains a steady voltage when discharged at high currents.

   b. Can be charged and discharged at a high rate of current without causing permanent damage.

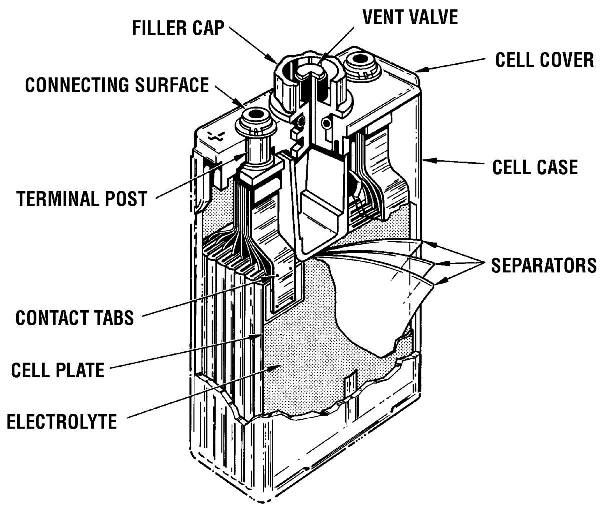
   c. Can be stored in any state of charge without any damage.

   d. Can withstand extremely cold temperatures without damage.

   e. Can withstand high levels of vibration and shock.

   f. Composed of individual, replaceable cells.

NI-CAD BATTERY CELL CONSTRUCTION



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NOTES

6. Principle parts of a cell

   a. Plates (electrodes) - plates are made of sintered carbon powder (called plaque) which produces a highly porous preform or carrier which is treated in the following manner.

      (1) Nickel oxide is used on the positive plates and metallic cadmium on the negative plates.

         (a) Positive plates are formed by soaking the preform in nickel salts and subjecting the salt-impregnated plate to electrical current.

         (b) Negative plates are formed by soaking the preform in cadmium salts and subjecting them to electrical current.

   b. Separator - a thin, porous piece of nylon and plastic that separates the positive and negative plates.

   c. Electrolyte - the electrolyte used in ni-cad batteries contains potassium hydroxide (KOH) which is a highly caustic chemical agent. When working around the battery, use protective rubber apron, gloves, and safety goggles. In case of accidental skin contact with electrolyte, immediately flush the affected area with cold water and seek immediate medical aid.

      (1) 30% solution (by weight) of potassium hydroxide (KOH) in distilled water.

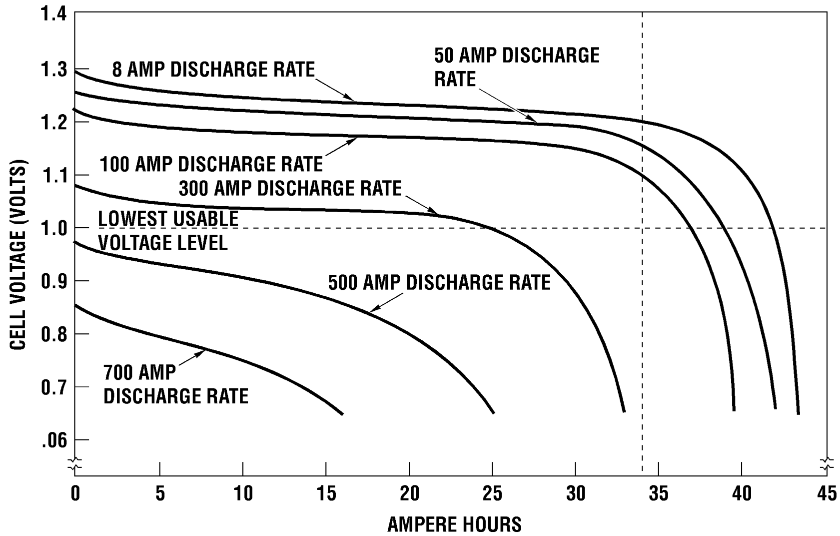
      (2) Electrolyte provides an ionized path for current to flow between the positive and negative plates.

      (3) Specific gravity of the electrolyte (1.300) remains the same whether the battery is charged or discharged.

      (4) Specific gravity cannot be used to determine the state of charge in a ni-cad battery.

   d. The battery is vented to prevent gases generated during the charging process from damaging the battery or creating a potentially explosive hydrogen gas build up. Venting allows the gas to escape from the cells in a gradual, controlled manner.

EFFECTS OF DISCHARGE RATES ON BATTERY CAPACITY



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NOTES

7. Considerations of operation based on an "aircraft-type" 30 amp-hour rating ni-cad battery.

   a. Availability of emergency power from the battery is defined as power available as long as individual cell output remains above one volt.

   b. Reduction of bus load by isolating the emergency bus is important to minimize the drain of power from a non-renewable source.

   c. Since the 100 amp discharge rate shown crossing the 1.0 volt per cell (lowest usable voltage level), is to the right of the 30 amp-hour published battery rating, it is evident that the published rating for the battery capacity is based on a current drain in excess of 100 amps for this series of battery.

8. Effects of discharge rates on battery capacity

   a. Lowest usable voltage per cell is 1 volt.

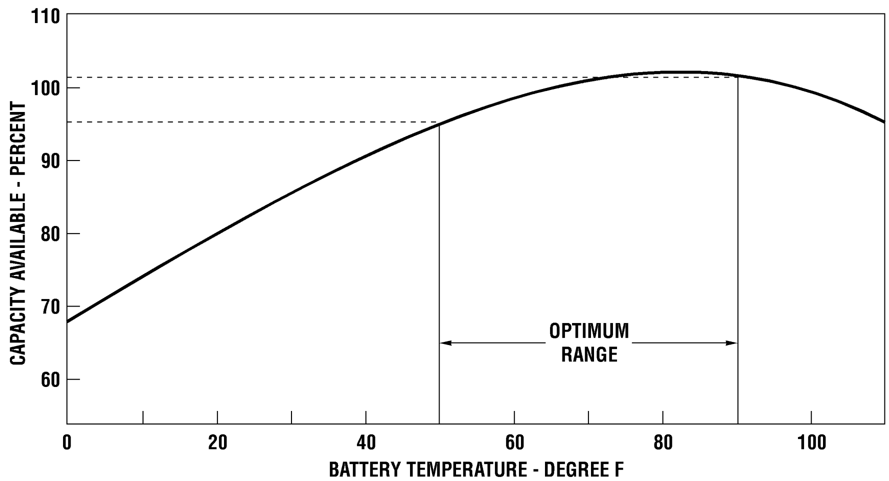
   b. With current demand of

      (1) 8 amps, the effective capacity of the battery is 41 amp-hours (i.e., 41 hours at a one amp rate, or 5.125 hours at the stated discharge rate)

      (2) 100 amps, the result is an effective capacity of 37 amp-hours, or about 22 minutes.

      (3) 300 amps, the result is an effective capacity of 25.4 amp-hours, or about 5 minutes.

AVAILABLE BATTERY
CAPACITY vs TEMPERATURE



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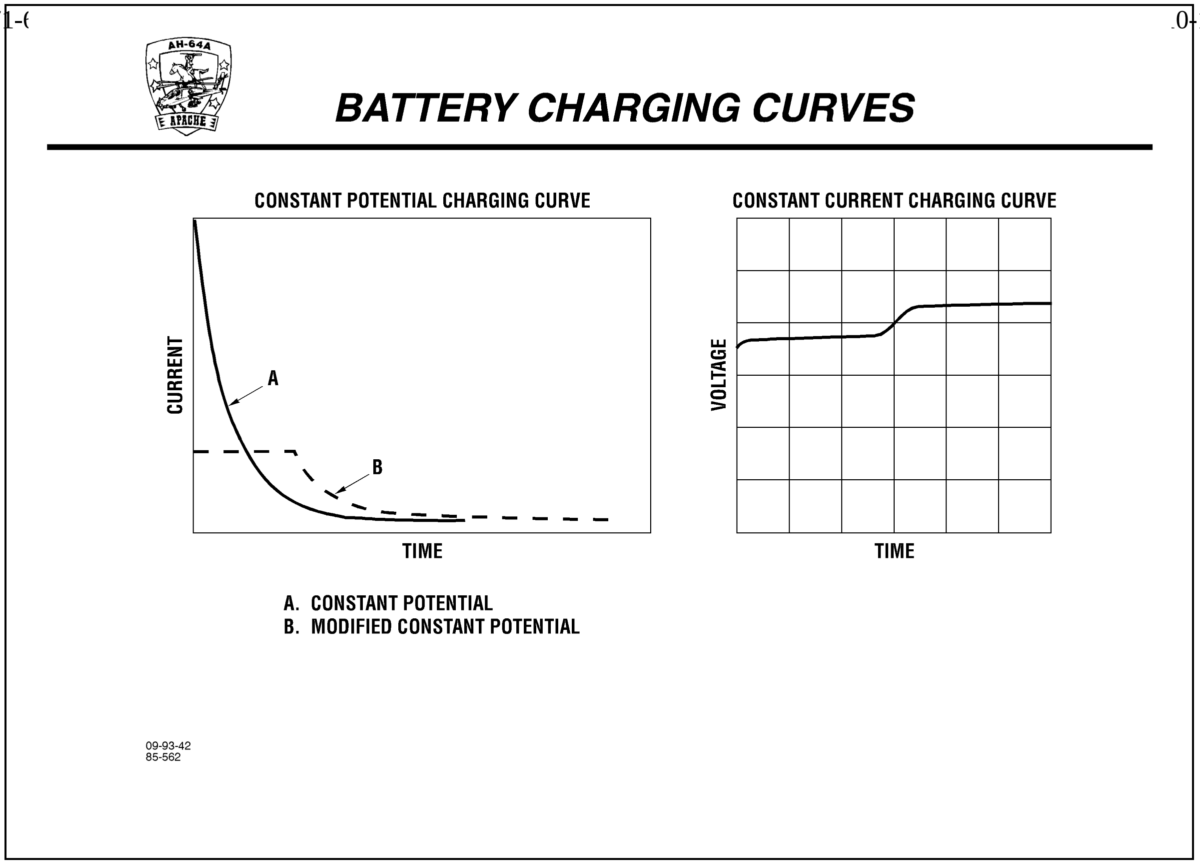
85-561

NOTES

9. Effects of temperature on capacity

   a. Optimum temperature range is from 50^{E} to 90^{E}F.

   b. Any increase or decrease in temperature from optimum causes a corresponding reduction in cell capacity.


AH-64A
APACHE
BATTERY CHARGING CURVES
CONSTANT POTENTIAL CHARGING CURVE
CURRENT
A
B
TIME
CONSTANT CURRENT CHARGING CURVE
VOLTAGE
TIME
A. CONSTANT POTENTIAL
B. MODIFIED CONSTANT POTENTIAL
09-93-42
85-562

NOTES

10. Typical battery charging curves

a. Constant potential charging

(1) Applies a fixed (constant) voltage to the cell.

(2) Resulting charge current is determined by the applied voltage level, the state of charge of the cell, and cell temperature.

(3) A very high current is input for a short period of time until the voltage of the battery rises as it nears full charge, or the temperature within the battery elevates.

b. Modified constant potential charging

(1) Some battery charging equipment cannot tolerate the very high currents which are initially drawn in the first stages of charging at constant potential. In such cases, current limiting devices, such as electrical resistances, are commonly connected between the battery and its charging source.

(2) This practice supplies a reduced voltage in the initial stage of charging and a fixed voltage when the battery is fully charged.

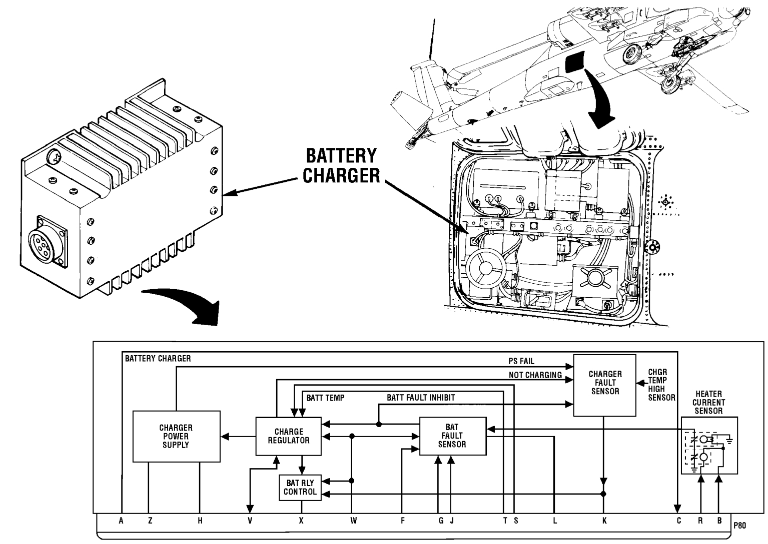
(3) The limitation of charging current during initial stages of charging lengthens the time required to completely charge the battery.

c. Constant current charging

(1) This method of charging is not limited by back voltage (internal resistance) of the battery. Battery voltages rises sharply as a 100% state of charge is reached. Charging current is still applied to achieve the desired 20% to 40% overcharge.

(2) The battery charger on the AH-64A is a constant current charger with a charging voltage limit.

BATTERY CHARGER



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85-552A

NOTES

E. Battery charger

1. Controls

a. Battery charging when DC essential bus 1 voltage is above 24 VDC and external power is not connected to the helicopter.

b. Battery to the emergency bus connection when DC essential bus 1 is 18 VDC or less.

c. HOT BAT and CHARGER caution lights using internal fault sensing circuits.

2. Located in the aft avionics bay.

3. Description

a. Compact, 5.2 pound, solid-state LRU.

b. A converter electronically chops the input voltage and connects it through step up/step down transformer to rectifier diodes and then regulates that output.

c. Contains two printed circuit cards and three transformers used by the transistors in the 28 VDC to 33.5 VDC convertor section of the power supply.

d. Two channel-type heat sinks are attached to the side of the molded aluminum case for heat dissipation. The power transistors are attached to each heat sink.

e. The front of the charger has one quick-disconnect receptacle for power and control connections.

f. The battery charger can

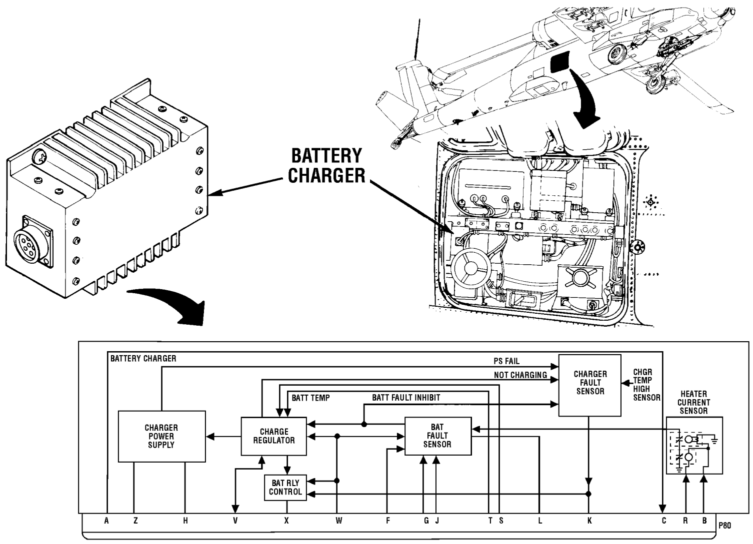
(1) Recharge a completely discharged battery in approximately 2.5 hours (13 amp/hr) 5.2 amps = 2.5 hr.)

(2) Stop charging the battery if battery temperature rises above 50^{o} "3^{o} C (122^{o}"5^{o}F) and resume charging when the temperature drops below 46^{o}"3^{o}C (115^{o} "5^{o}F).

(3) Stop battery charging if an open or short circuit occurs in the battery temperature transducer circuit.

(4) Stop or inhibit battery charging if the tenth cell voltage falls below or exceeds, respectively, 45 to 60% of battery terminal voltage for more than 3"0.6 minutes.

BATTERY CHARGER



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85-552A

NOTES

(5) Discontinue charging when external power is applied to the helicopter, preventing the buildup of explosive gases.

(6) Provide an indication to the pilot of battery or charger failure.

g. Internal circuits

(1) Charger power supply

(2) Charger regulator. (MWO 11-6610-366-30 reschedules battery charger charge rate to a revised schedule.)

(a) Maximum charge voltage is limited to 33.5" 0.5 volts.

(b) Maximum charge rate will be increased to 5.2 amps.

(3) Battery relay control

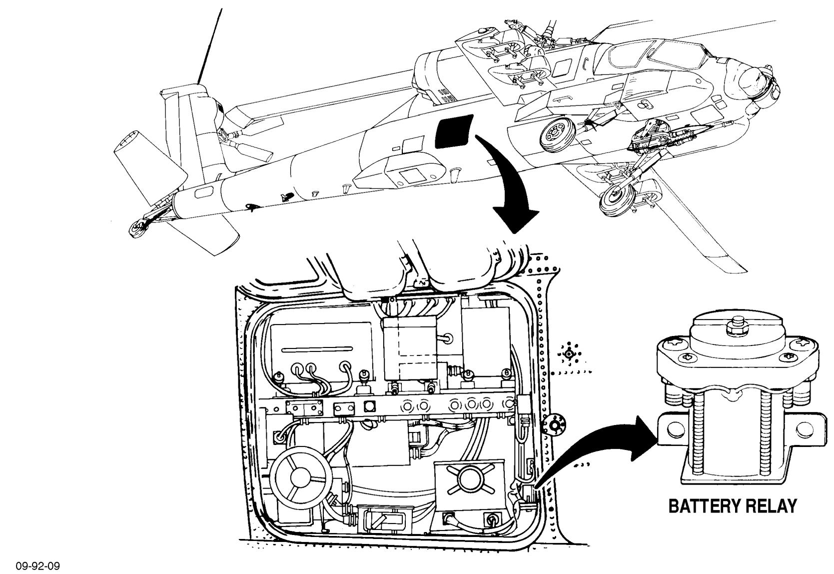
(4) Battery fault sensor

(5) Charger fault sensor

(6) Heater current sensor

 071-610-10

BATTERY RELAY



NOTES

F. Battery relay

1. When energized, connects the battery to the emergency bus.

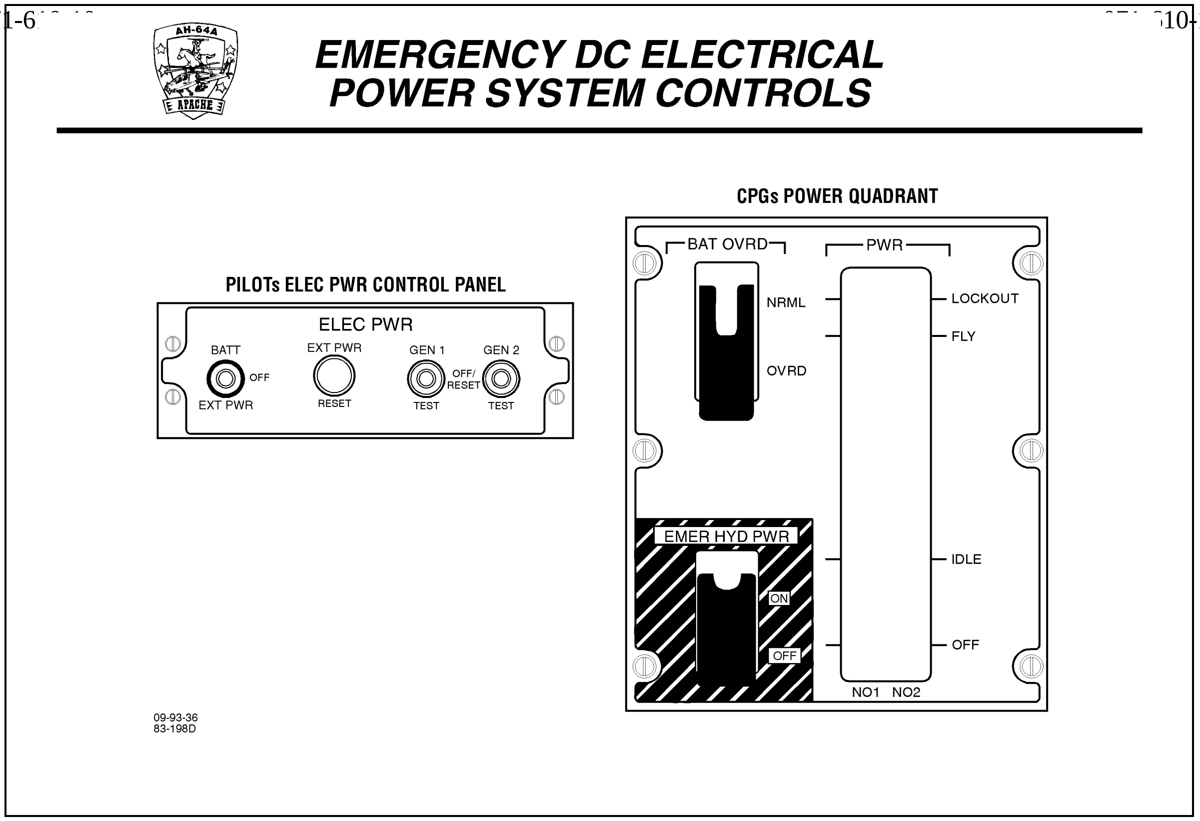
2. Is mounted in the aft avionics bay.

3. Description

   a. 2 inch x 2 inch, 1.40 pound relay, with two large high current, and two small control terminal studs for 24 VDC battery power and control connections.

   b. The battery charger causes the battery relay to connect the battery to the emergency bus when the DC essential bus 1 falls below 18 VDC.

   c. The battery relay will maintain the battery connection until the battery voltage drops below 9 VDC (as in a discharged state).


AH-64A
APACHE
EMERGENCY DC ELECTRICAL
POWER SYSTEM CONTROLS
CPGs POWER QUADRANT
PILOTs ELEC PWR CONTROL PANEL
ELEC PWR
BATT
OFF
EXT PWR
EXT PWR
RESET
GEN 1
OFF/
RESET
TEST
GEN 2
TEST
BAT OVRD
NRML
OVRD
PWR
LOCKOUT
FLY
IDLE
OFF
NO1 NO2
EMER HYD PWR
ON
OFF
09-93-36
83-198D

NOTES

G. Emergency DC electrical power system controls

1. BATT/OFF/EXT PWR switch

a. Allows the pilot to connect the battery to the emergency DC bus when placed in the BATT position.

b. Located on the pilot's electrical power control panel on the left console.

c. Double-pole, double-throw, three-position switch

(1) BATT position provides a ground for the battery relay via the CPG BAT OVRD switch.

(2) EXT PWR position is used to apply external power.

(3) OFF position interrupts ground for the

(a) Battery relay coil.

(b) External power contactor relay coil.

2. CPG BAT OVRD switch

a. Allows the CPG to disconnect the battery in the event of an emergency not requiring the battery, thus reducing electrical fire hazards. It is an interlock component that enables the connection of the battery to the emergency DC bus.

b. Located on the CPG's power quadrant on the left console.

c. Single pole, double-throw, two-position switch with a guard.

(1) NRML position

(a) Completes a circuit from the pilot's BATT/OFF/EXT PWR switch to the battery relay coil.

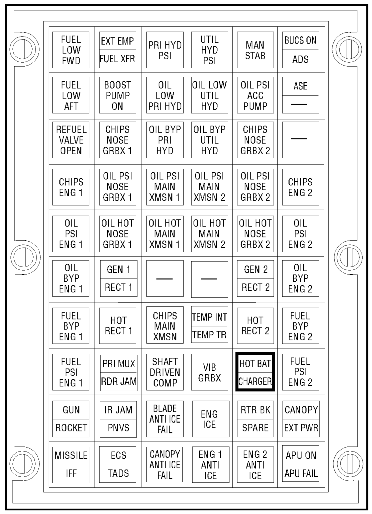
(b) When the switch guard is down, the switch is locked in the NRML position to prevent disconnecting the battery, inadvertently.

(2) BATT OVRD position interrupts the circuit to the battery relay coil to disconnect the battery.

d. The CPG's BATT OVRD switch must be in the NRML position and the pilot's BATT/OFF/EXT PWR switch must be in the BATT position for the battery to be connected to the emergency bus.

EMERGENCY DC ELECTRICAL SYSTEM CAUTION LIGHTS

PILOTs CAUTION/WARNING/ADVISORY PANEL



83-502

NOTES

H. Caution lights

1. HOT BAT

a. Advises the pilot that the battery has overheated, a cell imbalance exists, or that battery heater current is insufficient.

b. Located on the pilot's caution/warning/advisory panel.

c. Amber-colored light that illuminates when

(1) The battery overheats and temperature exceeds 57°" 3°C (135°F"5°F).

(2) A cell voltage imbalance exists for more than 3 "0.6 minutes.

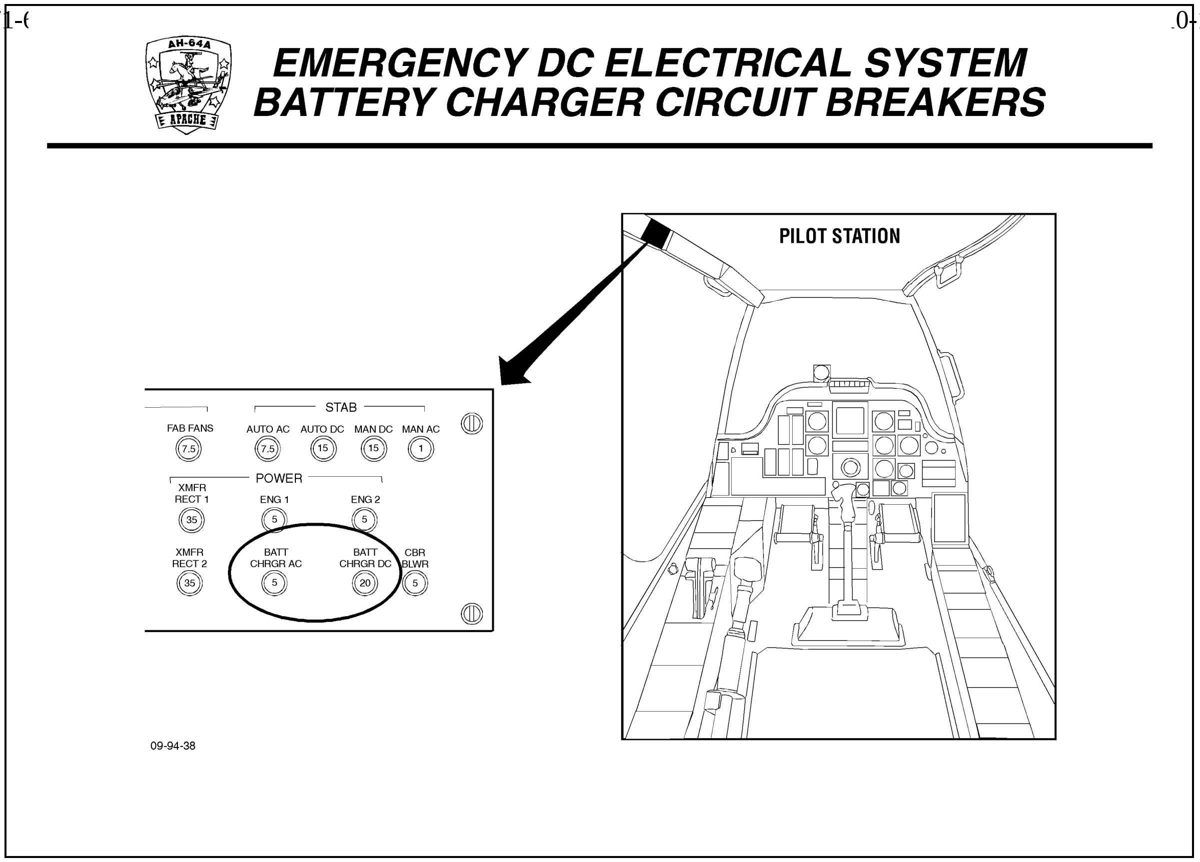
(3) Heater current is insufficient.

2. CHARGER

a. Advises the pilot that the charger is not charging the battery, except when charging is terminated as a result of a charge completion or overtemperature.

b. Located on the pilot's caution/warning/advisory panel.

c. Is an amber-colored light.


AH-64A
APACHE
EMERGENCY DC ELECTRICAL SYSTEM
BATTERY CHARGER CIRCUIT BREAKERS
PILOT STATION
STAB
FAB FANS
AUTO AC
AUTO DC
MAN DC
MAN AC
7.5
7.5
15
15
1
POWER
XMFR
RECT 1
ENG 1
ENG 2
35
5
5
XMFR
RECT 2
BATT
CHRGR AC
BATT
CHRGR DC
CBR
BLWR
35
5
20
5
09-94-38

NOTES

I. Circuit breakers

1. BATT CHGR DC circuit breaker

a. Connects DC essential bus 1 power to the battery charger.

b. Located on the pilot's aft overhead circuit breaker panel.

c. Description

(1) Rated at 28 VDC, 20 amperes.

(2) Powered by the DC essential bus 1.

2. BATT CHGR AC circuit breaker

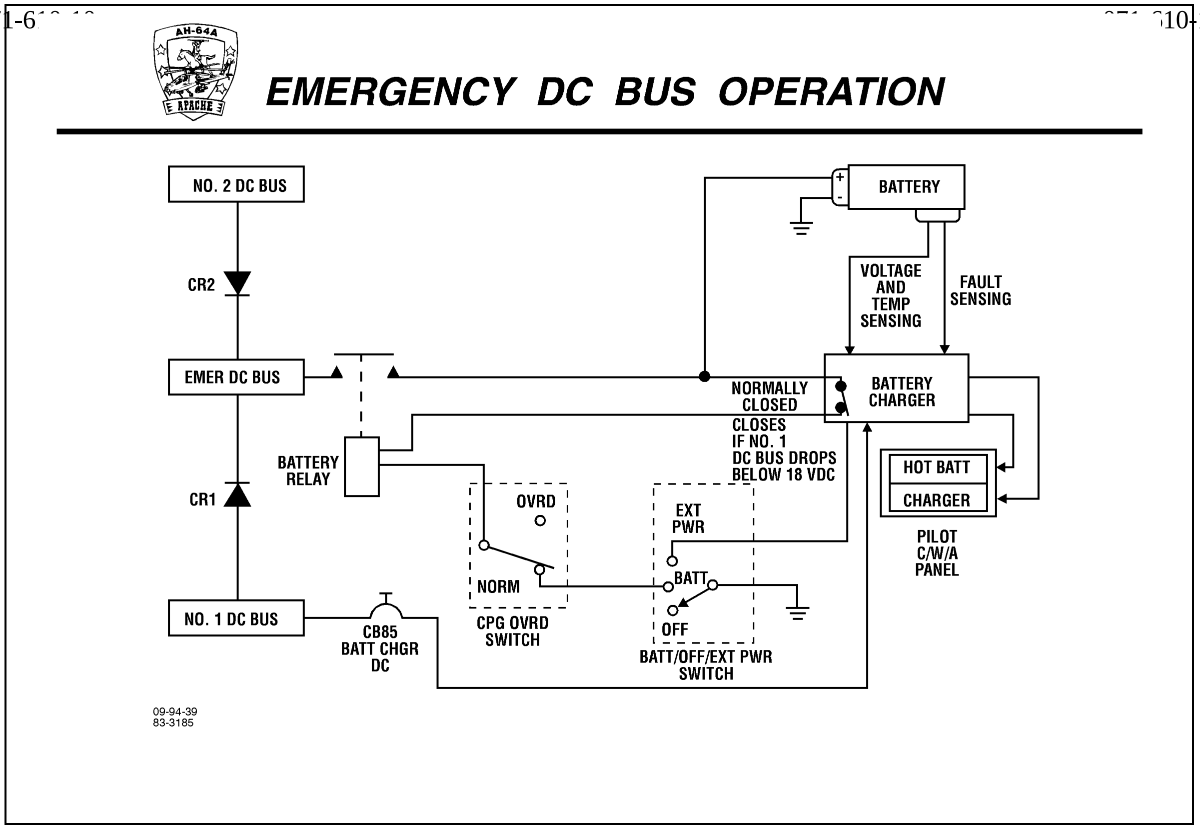
a. Connects AC essential bus 2, phase C power to the battery charger for battery heater operation.

b. Located on the pilot's aft overhead circuit breaker panel.

c. Description

(1) A single-phase circuit breaker rated at 115 VAC, 5 amps.

(2) Powered by the AC essential bus 2, phase C.


AH-64A
APACHE
EMERGENCY DC BUS OPERATION
NO. 2 DC BUS
CR2
EMER DC BUS
BATTERY RELAY
CR1
NO. 1 DC BUS
CB85
BATT CHGR
DC
OVRD
NORM
CPG OVRD SWITCH
EXT PWR
BATT
OFF
BATT/OFF/EXT PWR SWITCH
BATTERY
VOLTAGE AND TEMP SENSING
FAULT SENSING
NORMALLY CLOSED
CLOSES IF NO. 1 DC BUS DROPS BELOW 18 VDC
BATTERY CHARGER
HOT BATT
CHARGER
PILOT C/W/A PANEL
09-94-39
83-3185

NOTES

A. Emergency DC bus operation

1. Normal operation

a. When the battery quick-disconnect connectors are connected, battery voltage is applied to the battery charger, the open contacts of the battery relay, and the coil of the battery relay through the battery charger.

b. With no other source of electrical power on the aircraft and the CPG's battery override switch in the NORM position, placing the BATT/OFF/EXT PWR switch in the BATT position applies a ground to the coil of the battery relay.

c. 24 VDC from the battery is connected to the battery relay, normally open, high current contacts.

d. 24 VDC from the battery is also connected to the normally closed battery relay control circuit (represented by a switch).

e. 24 VDC from the battery is connected through the normally closed battery relay control circuit to the battery relay coil.

f. The battery relay energizes and connects the battery to the emergency DC bus. The battery now provides 24 VDC power to the helicopter systems that are powered by the DC emergency bus.

g. Battery power is isolated from the emergency bus by CR1 and CR2 (these diodes are reverse-biased with respect to the # 1 and # 2 DC essential buses) and prevent the battery from powering equipment other than those on the DC emergency bus.

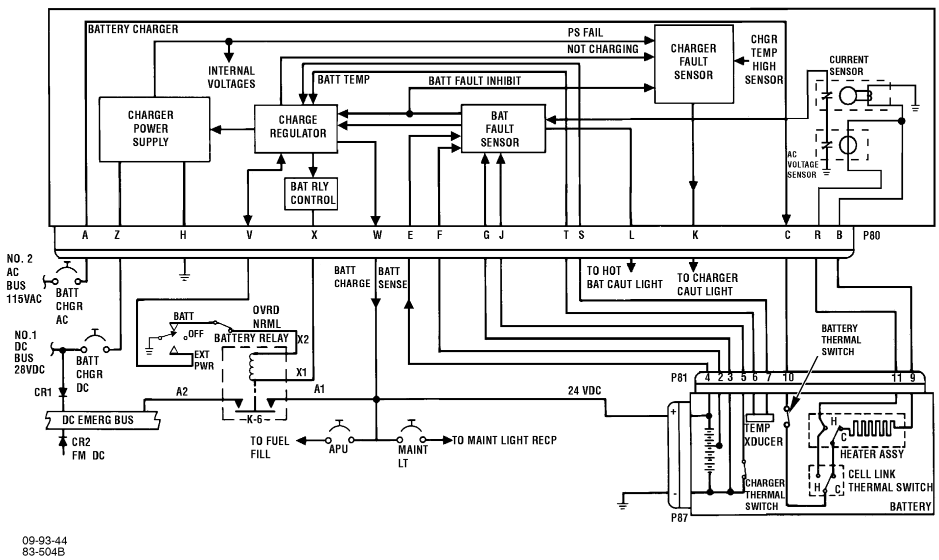
h. When DC essential bus 1 is energized, 28 VDC is applied to the battery charger, via the POWER BATT CHGR DC circuit breaker.

i. The battery charger, battery relay control circuit, de-energizes the battery relay by opening the circuit to the battery relay coil.

j. As long as the DC essential bus 1 has at least 18 VDC applied, the battery charger will maintain an open circuit to the coil of the battery relay and keep the battery in a charged state.

k. If voltage on the DC essential bus 1 drops below 18 VDC, the battery charger automatically closes the circuit to the battery relay coil, connecting the battery to the emergency DC Bus. The battery remains connected as long as the DC essential bus 1 voltage is below 18 VDC, or until battery voltage is depleted below 9 VDC, then the helicopter will be without electrical power.

EMERGENCY DC ELECTRICAL POWER SYSTEM FUNCTIONAL DIAGRAM



NOTES

2. Charging operation

a. The battery charger is supplied with 28 VDC power from the DC essential bus 1, via the 20 amp POWER BATT CHGR circuit breaker at P80, pin Z.

b. As long as 28 VDC is present and remains above 18 VDC, the charger maintains on open circuit at P80, pin X. Internal to the charger, the input, 18 to 28 VDC, voltage is applied to a 28 VDC to 33.5 VDC converter.

c. The 33.5 VDC output is regulated to 33.5 + 0.5 volts and is the voltage available to charge the battery at a constant current rate.

d. The 33.5 VDC battery charging voltage is applied to P80, pin W.

e. The 33.5 VDC battery charging voltage is also applied to the battery relay control circuit. This keeps battery relay K6 de-energized and prevents the battery from supplying power to the DC emergency bus while it is charging.

f. The 33.5 VDC battery charging voltage from P80, pin W, is applied to

(1) the open, high current, contacts of the battery relay, K6, A1.

(2) The APU and MAINT LT circuit breakers.

(3) The battery wire, from the battery relay, K6, A1, to the battery quick disconnect connector, P87 positive terminal.

g. Temperature from the battery temperature transducer is applied to the charger at P80, pins T and S, and is routed to the charger regulator.

h. Battery voltage is sensed internally, at the +24 VDC terminal, and is applied to P81, pin 4.

i. From P81, pin 4, battery voltage is applied to P80, pin E.

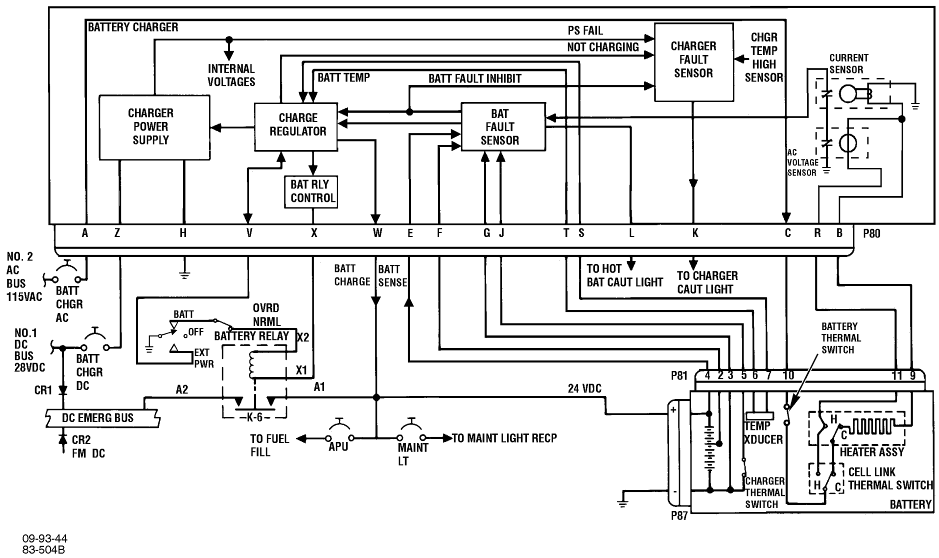
j. From P80, pin E, battery voltage is applied to the charge regulator, via the battery fault sensor.

k. Using these inputs, the charger regulator determines the battery charge requirements.

l. The maximum charge rate is set at 5.2 amps.

m. The charge current path is from ground, via the negative terminal of P87, to the negative side of the battery, through the battery cells in a negative to positive direction, to the positive terminal of P87, out of the positive terminal, through the battery wire, to the battery relay, K6, A1, to P80, pin W, of the charger, to the charge regulator circuit, and through the charger power supply under the control of the charge regulator and then back to the 28 VDC source at P80, pin Z.

EMERGENCY DC ELECTRICAL POWER SYSTEM FUNCTIONAL DIAGRAM



NOTES

n. When the battery is fully charged, a topping voltage 1.5 VDC greater than battery terminal voltage is maintained by the battery charger.

o. Battery charging is inhibited by a ground at P80, pin V, from the BATT/EXT PWR switch during external ground power operation.

3. Heater operation

a. 115 VAC, phase C from the AC essential bus 1 is applied to P80, pin A, of the battery charger.

b. The battery charger connects the 115 VAC out P80, pins C and R, to P81, pins 10 and 11, to the internal heater assembly of the battery.

c. When the temperature is below -5°C (23°F), the heater assembly and the cell link thermal switches are both in the cold position.

d. Power is applied to the heater element via P81, pin 9, and into the battery charger at P80, pin B.

e. The battery charger provides a return path for the power and the heater current sensor monitors the return current.

f. When the internal battery temperature rises above 0°"5°C (32°"9°F), the cell-linked thermal switch moves to the hot position and disconnects heater power.

g. If the cell-linked thermal switch fails in the cold position, the heater thermal switch moves to the hot position when heater temperature rises above 110°C (230°F) and disconnects the heater.

4. Components connected to the battery

a. The battery is connected directly to the maintenance light (MAINT LT) circuit breaker and the APU circuit breaker. The APU circuit breaker is connected directly to the FUEL FILL circuit breaker.

b. These connections provide battery voltage for operating the maintenance light, APU start, and refueling operations any time the battery connecter is connected.

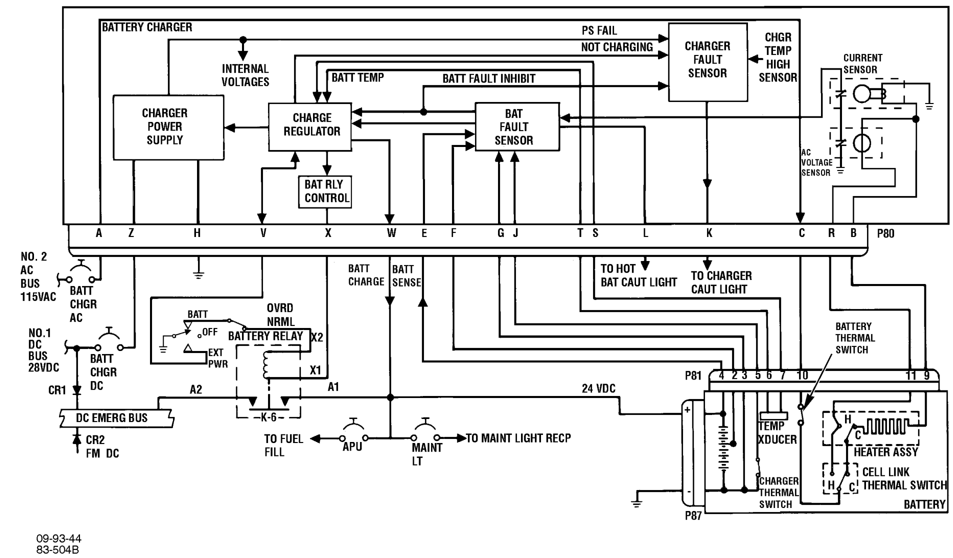
5. Fault sensing

a. The battery fault sensing logic receives four inputs from the battery

(1) Battery temperature

(2) Battery 10th cell voltage

EMERGENCY DC ELECTRICAL POWER SYSTEM FUNCTIONAL DIAGRAM



NOTES

(3) Battery voltage (19th cell)

(4) Battery heater current

b. The fault sensing logic

(1) Compares the ratio of the 10th cell voltage, to the 19th cell voltage. If an imbalance exists, a battery fault is detected.

(2) If the battery overheats, the battery overtemperature thermal switch closes and a battery fault is detected.

(3) If battery heater current is insufficient, a battery fault is detected.

c. Detection of a BATTERY FAULT causes the battery fault inhibit signal to disable part of the charger fault sense logic.

(1) The battery fault inhibit disables the charger regulator to prevent battery charging.

(2) The HOT BAT segment on the pilot's caution/warning/advisory panel illuminates.

d. If there is no battery failure, the charger fault sense logic monitors three inputs

(1) Charger temperature

(2) Charger power supply

(3) Charge regulator output

e. A charger fault is detected if the

(1) Power supply fails.

(2) Charger regulator has no output.

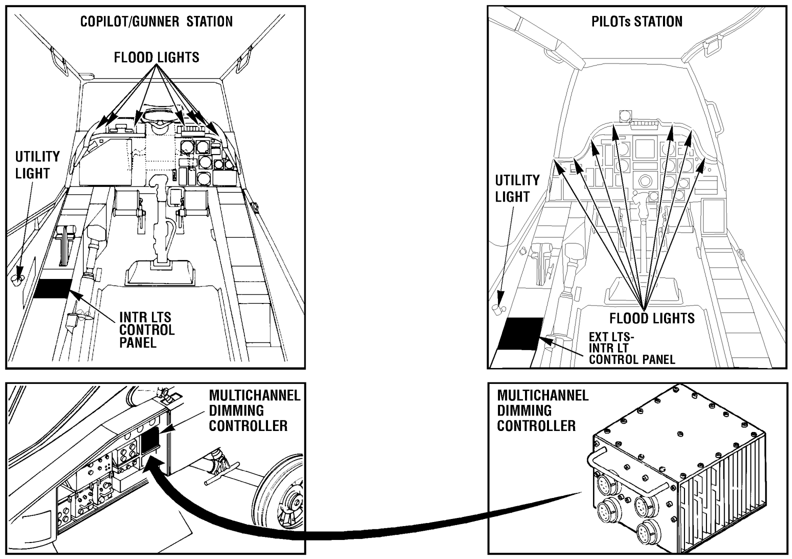
(3) Charger overheats.

f. Detection of a CHARGER FAULT by the sense logic will cause the charger to connect

(1) A ground to the CHARGER light on the pilot's caution/warning/advisory panel

(2) Power to the battery relay to energize the battery relay.

INTERIOR LIGHTING COMPONENTS



86-25

NOTES

A. Interior lighting system

1. Provides variable intensity panel lighting, instrument lighting, general crewstation lighting, and emergency lighting for the instrument panels and crewstations.

2. Interior lighting components

    a. Lighting control panel (pilot's and CPG's)

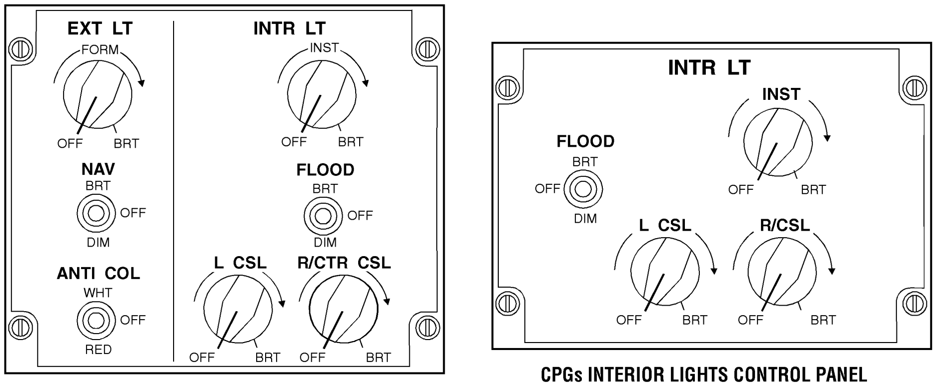
    b. Utility lights (pilot's and CPG's)

    c. Flood lights (pilot's and CPG's)

    d. Multichannel dimming controller

071-610-10

PILOTs EXT LTS-INTR LTS AND CPG INTR LTS PANELS



PILOTs INTERIOR/EXTERIOR LIGHTS CONTROL PANEL

CPGs INTERIOR LIGHTS CONTROL PANEL

83-48B

NOTES

B. Component purpose, location, description, and operation

1. Lighting control panels

a. Provide the crew members with a means of controlling the instrument, flood, and console lights in the respective crewstations.

b. Location

(1) The pilot's EXT LTS - INTR LTS control panel is located in the pilot's left console.

(2) The CPG's INTR LTS control panel is located in the CPG's left console.

c. Description and operation

(1) Pilot's EXT LT - INTR LTS control panel

(a) The pilot's lighting control panel contains two areas for controlling the exterior and interior lights.

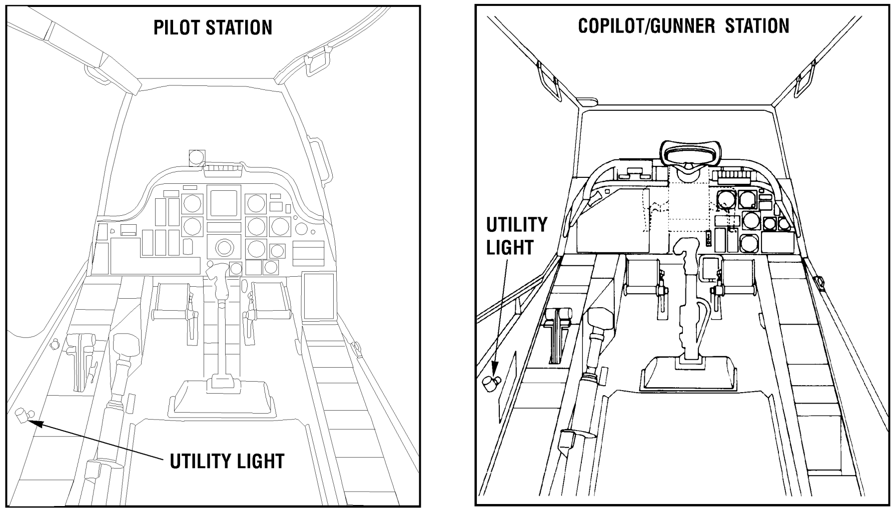
(b) The INTR LT control panel has three rheostat switches and one three-position toggle switch.

d. CPG's INTR LT control panel has three rheostat switches and one three-position toggle switch.

e. Operation of the two control panels is identical.

071-610-10

UTILITY LIGHTING LOCATION



86-27

NOTES

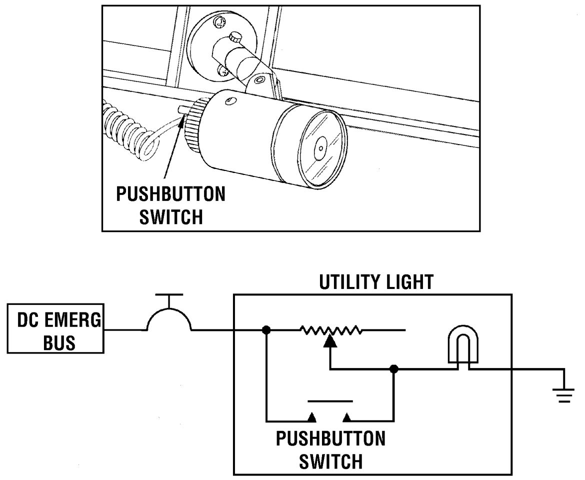
2. Utility lights

   a. Provide the pilot and CPG with a red or white lighting capabilities in case instrument lighting fails.

   b. One utility light is located in each crewstation, on the left bulkhead above the lighting control panel.

071-610-10

PILOTs OR CPGs UTILITY LIGHT



83-49B

NOTES

c. Description

(1) Are standard 28 VDC Grimes lights.

(2) Has a telephone-type self-retracting power cord, which allows the light to be detached from its mount and manually hand positioned by the crew member.

(3) The lights have red and clear lenses.

(4) The lights have a switch/rheostat and momentary switch button mounted on the back of the light to give on-adjust/off and off (dim)/bright control.

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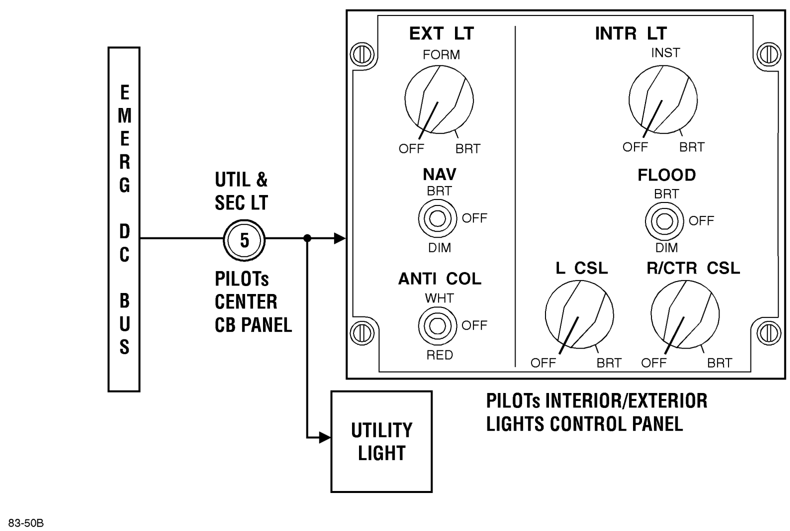
UTILITY LIGHT OPERATION



NOTES

d. The pilot and CPG utility lights are identical in appearance and operation.

e. Emergency DC bus power is applied to the utility lights through the UTIL & SET SEC circuit breaker.

   (1) The pilot UTIL and SEC LT circuit breaker is located on the pilot center circuit breaker panel.

   (2) The CPG UTIL and SEG LT circuit breaker is located on the CPG console circuit breaker panel.

f. When the utility light switch/rheostat is rotated clockwise out of the off detent, the light illuminates and increases in intensity until the rotation limit is reached.

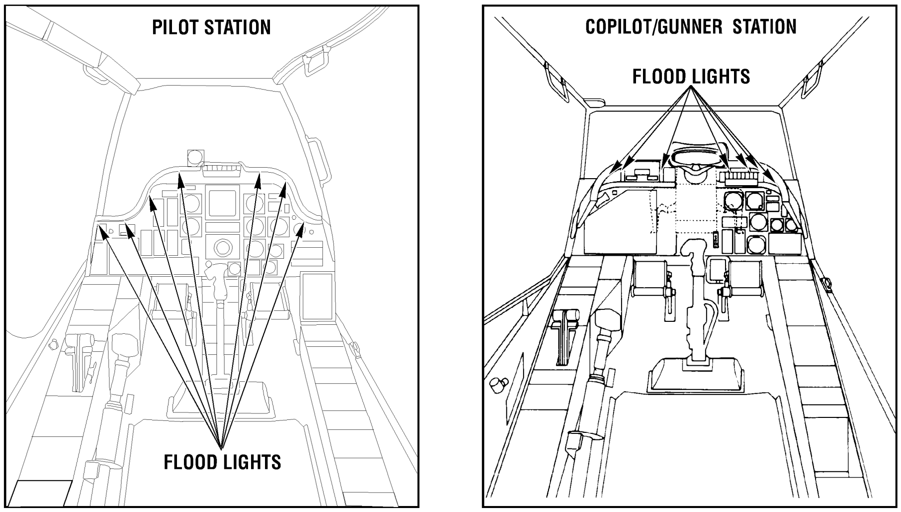
g. When the switch/rheostat is rotated counter-clockwise, the light dims until the off detent position is reached.

h. Regardless of the position of the switch/rheostat, depressing the momentary switch button causes the utility lamp to illuminate at maximum intensity.

i. A red or clear lens can be selected.

j. The utility light operates independent of the lighting control panels.

FLOOD LIGHT LOCATION



86-28A

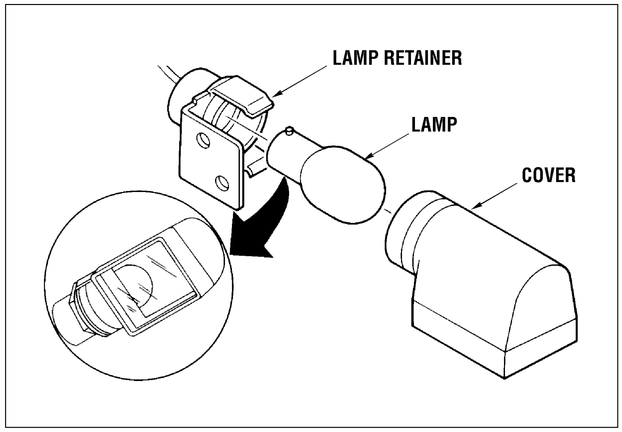
NOTES

3. Floodlights

   a. Provide emergency illumination of the instrument panel in case of multichannel dimmer output loss.

   b. There are seven floodlights spaced across the glare shield above each crewstation instrument panel.

PILOTs OR CPGs EMERGENCY FLOODLIGHT LAMP



83-51A

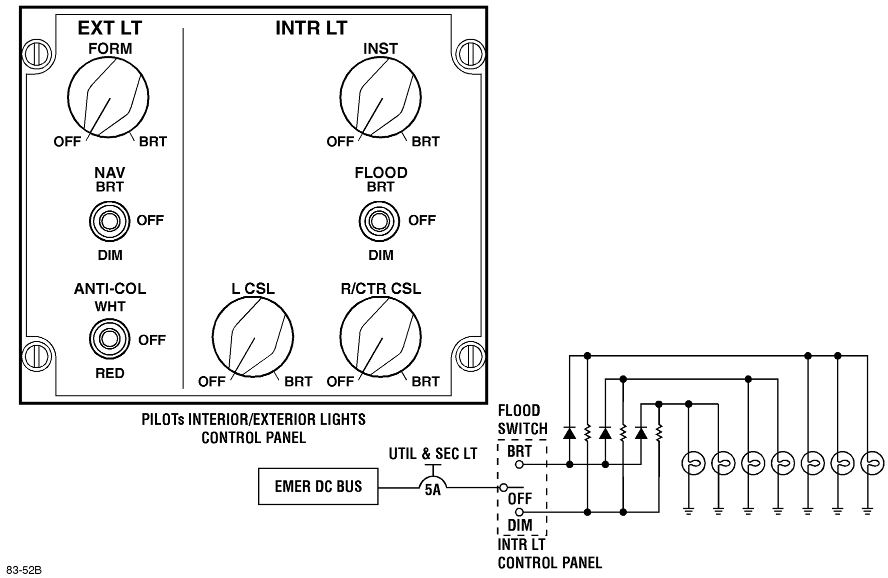
NOTES

c. The pilot and CPG floodlights are identical in appearance and operation.

d. The assemblies consist of a lamp, a lamp cover with a blue lens, and a lamp retainer.

e. Emergency DC bus power is applied to the FLOOD switches mounted in the INTR LT control panel via the pilot and CPG UTIL & SEC LT circuit breakers.

FLOODLIGHT OPERATION



NOTES

f. The FLOOD switches are three-position toggle switches.

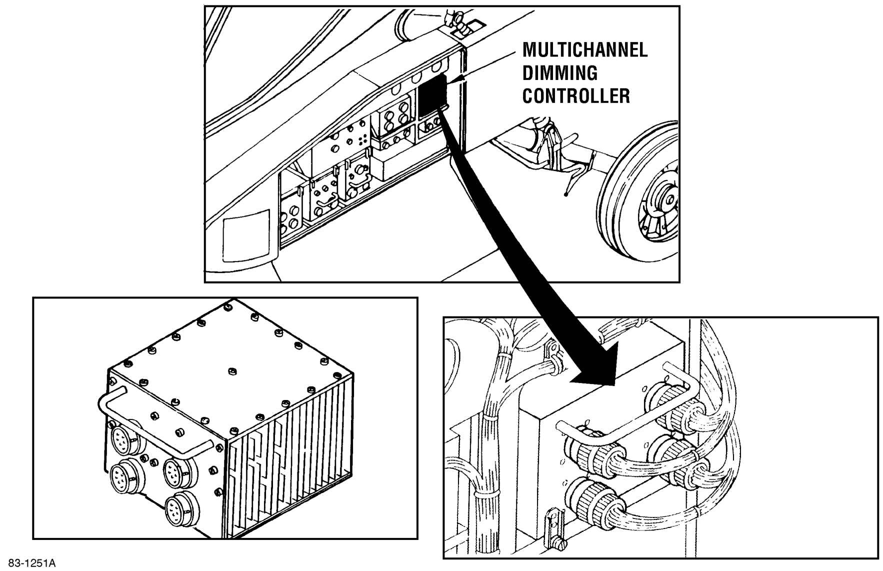
(1) OFF (center) position extinguishes all floodlights in the respective crewstation.

(2) BRIGHT position applies 28 VDC through three isolation diodes to three groups of flood lamp assemblies which provide bright blue lighting for the instrument panel.

(3) DIM position applies the 28 VDC through three voltage dropping resistors to the same three groups of flood lamp assemblies and provide dim blue lighting for the instrument panel. The resistors reduce the intensity of the flood lamps by reducing current flow through the bulb filament.

071-610-10

MULTICHANNEL DIMMING CONTROLLER



NOTES

4. Multichannel dimming controller

a. Provides appropriate voltages for operation and dimming of

(1) Engine instruments

(2) Flight instruments

(3) All panel and console lighting

(4) Caution/warning/advisory panels

(5) Master caution/warning panels

(6) All remote indicator lights

b. Located in the left forward avionics bay, on the top shelf in the rear of the compartment.

c. Description

(1) Solid state, LRU

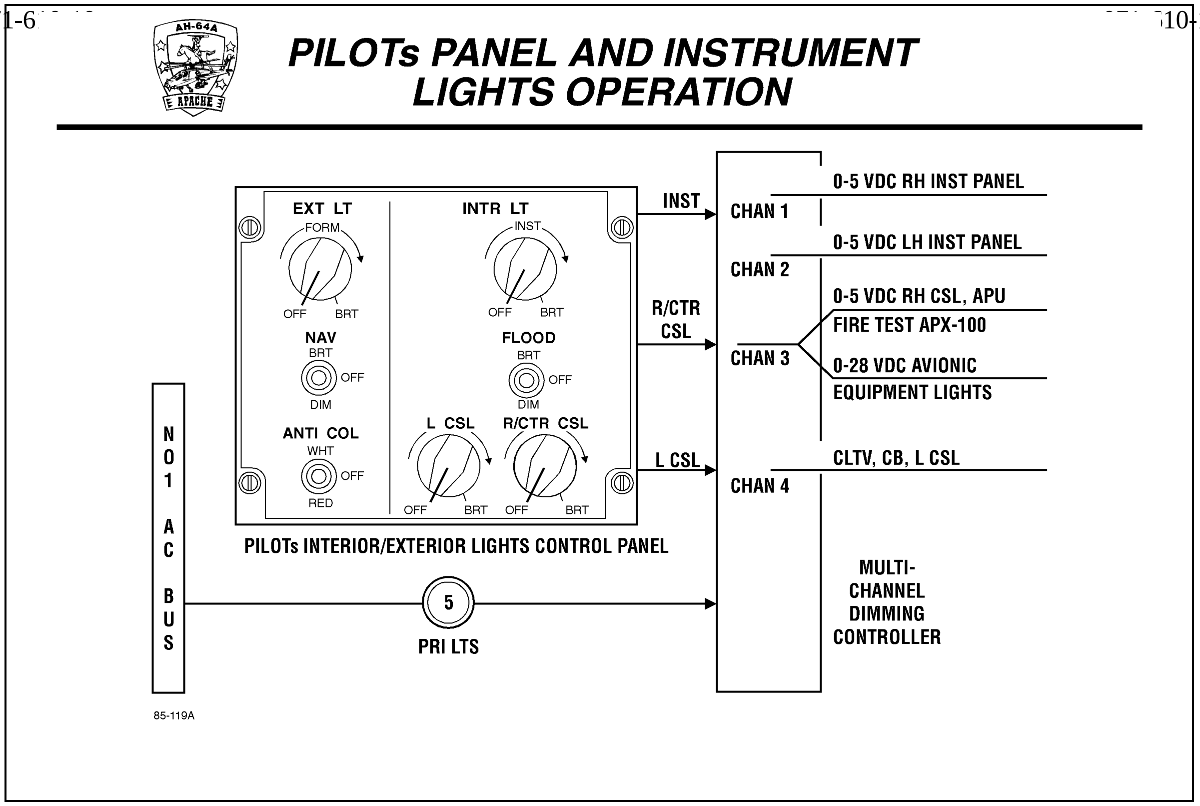
(2) The case has cooling fins that slide into a cooling shroud to provide cooling air received from the helicopter environmental control system.

(3) The controller has four quick-disconnect connectors.

(a) J1 and J2 provide dimming for the pilot crewstation.

(b) J3 and J4 provide dimming for the CPG crewstation.

071-610-10



NOTES

d. Pilot crewstation control of multichannel dimmer controller operation

(1) AC essential bus 1, phase A, 115 VAC is applied via the PRI LTS circuit breaker to the controller.

(2) The controller converts the 115 VAC input power to the proper DC levels under the control of the three switch/rheostats on the INTR LTS control panel.

(a) INST

(b) L CSL

(c) R/CEN CSL

(3) The controller has four channels

(a) Channels 1 and 2 control the lights on the right and left instrument panels, respectively.

(b) Channels 1 and 2 output voltages are 0 to 5 VDC controlled by the INST LT switch/rheostat.

(c) Rotating the INST LT switch clockwise from the detent position increases the intensity of the instrument lights to a maximum at the BRT position.

(d) Channel 3 controls the right and center console lights. It is controlled by the R/CTR CSL switch/rheostat and has both a zero to 5 VDC output and a zero to 28 VDC output.

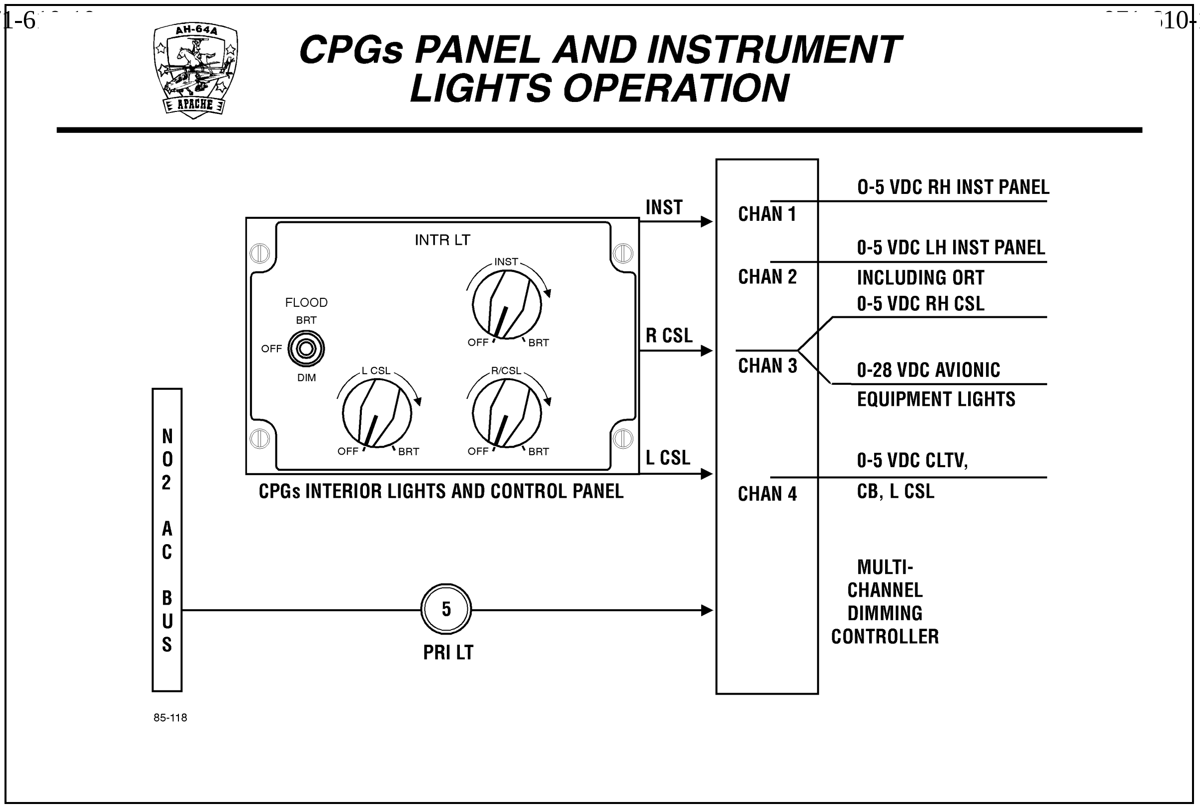
(e) Rotating the R/CTR CSL clockwise from the detent position increases the intensity of

1) The APU FIRE TEST and APX-100 control panel lights and the right console lighting as the controller voltage approaches 5 VDC.

2) The avionics equipment lights as the zero to 28 VDC controller output approaches its maximum.

(f) Channel 4 provides 0 to 5 VDC to the left console, the circuit breaker panels, and the collective switch box lights. It is controlled by the L CSL switch/rheostat.

(g) Clockwise rotation of the L CSL switch/rheostat from the detent position increases the intensity of the lights as the controller voltage approaches the 5 VDC available at the BRT position.


AH-64A
APACHE
CPGs PANEL AND INSTRUMENT
LIGHTS OPERATION
INTR LT
FLOOD
BRT
OFF
DIM
INST
OFF
BRT
L CSL
OFF
BRT
R/CSL
OFF
BRT
CPGs INTERIOR LIGHTS AND CONTROL PANEL
INST
R CSL
L CSL
CHAN 1
CHAN 2
CHAN 3
CHAN 4
0-5 VDC RH INST PANEL
0-5 VDC LH INST PANEL
INCLUDING ORT
0-5 VDC RH CSL
0-28 VDC AVIONIC
EQUIPMENT LIGHTS
0-5 VDC CLTV,
CB, L CSL
MULTI-
CHANNEL
DIMMING
CONTROLLER
NO 2 AC BUS
5
PRI LT
85-118

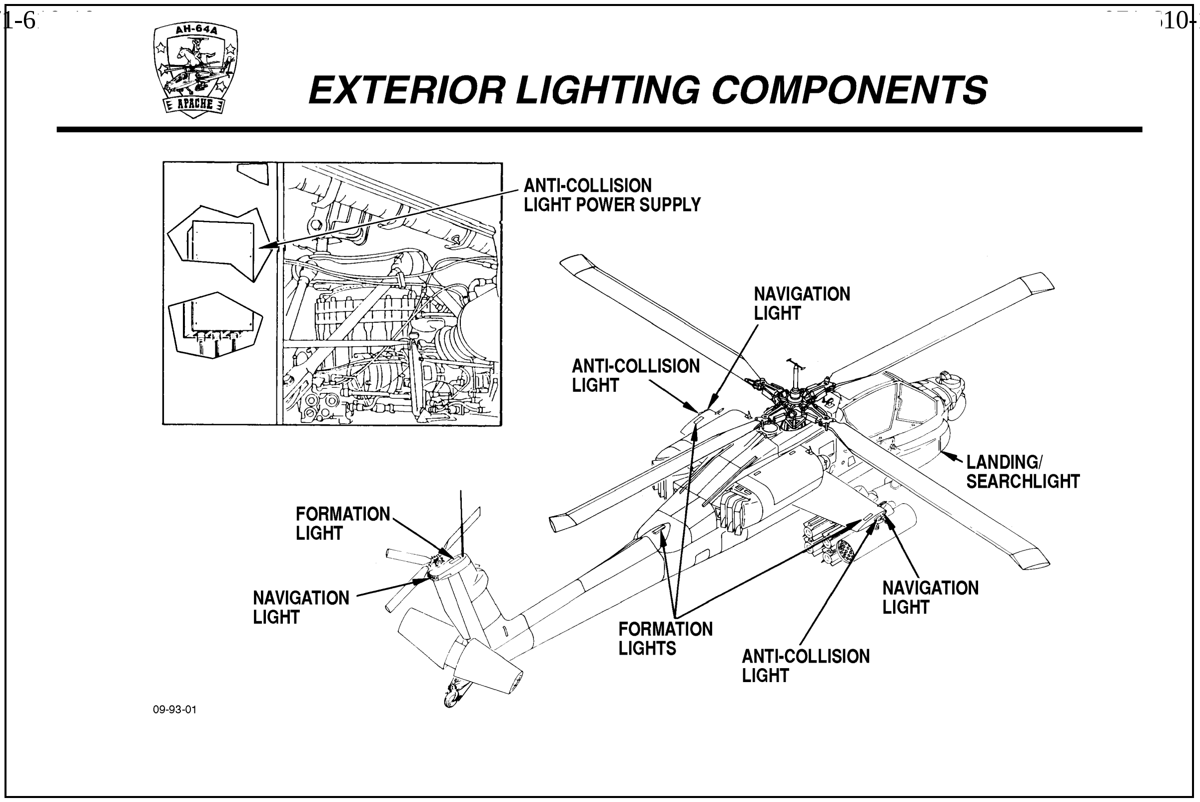
NOTES

e. CPG crewstation control of the multichannel dimmer controller

(1) The CPG's section of the multichannel dimming controller has the same four channel partitions as the pilot's and is controlled by the CPG's interior lights control panel in the same manner.

(a) Channels 1, 2 and 4 are low voltage controllable lamp drivers controlled by the INST and LCSL switch-rheostats.

(b) Channel 3, with its low voltage light driver for the ASN-124 or ASN-137 (doppler) and zero to 28 VDC drivers for the avionics lighting, is controlled by the R/CSL switch-rheostat.


EXTERIOR LIGHTING COMPONENTS
ANTI-COLLISION
LIGHT POWER SUPPLY
NAVIGATION
LIGHT
ANTI-COLLISION
LIGHT
LANDING/
SEARCHLIGHT
FORMATION
LIGHT
NAVIGATION
LIGHT
NAVIGATION
LIGHT
FORMATION
LIGHTS
ANTI-COLLISION
LIGHT
09-93-01

NOTES

A. Exterior lighting system

1. Exterior lights provide position and collision avoidance and also has a remote-steering, high-intensity flood light for search and ground safety.

2. Exterior lighting components

   a. Exterior lights and control panels

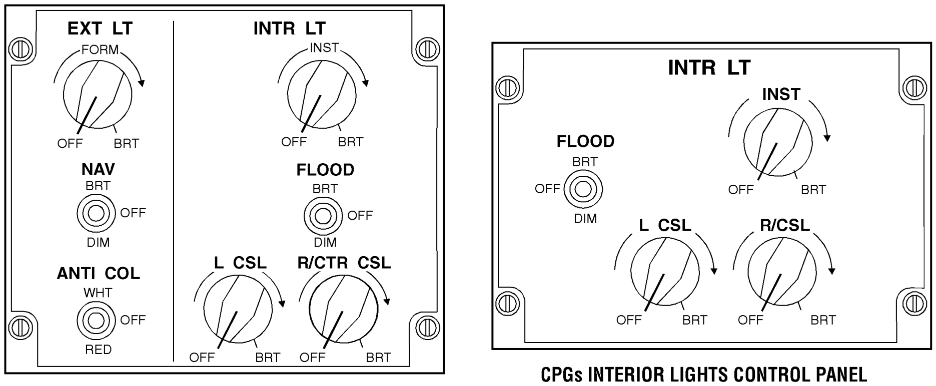
   b. Formation lights

   c. Anti-collision lights

   d. Navigation lights

   e. Landing/searchlight

PILOTs EXT LTS-INTR LTS AND CPG INTR LTS PANELS



PILOTs INTERIOR/EXTERIOR LIGHTS CONTROL PANEL

CPGs INTERIOR LIGHTS CONTROL PANEL

83-48B

NOTES

B. Component purpose, location, description, and operation

1. Pilot's EXT LTS - INTR LTS control panel

a. Provide the pilot with a means of controlling the formation lights, anti-collision lights, and the navigation lights from the pilot crewstation.

b. The pilot's EXT LTS - INTR LTS control panel is located in the pilot's left console.

c. Description and operation

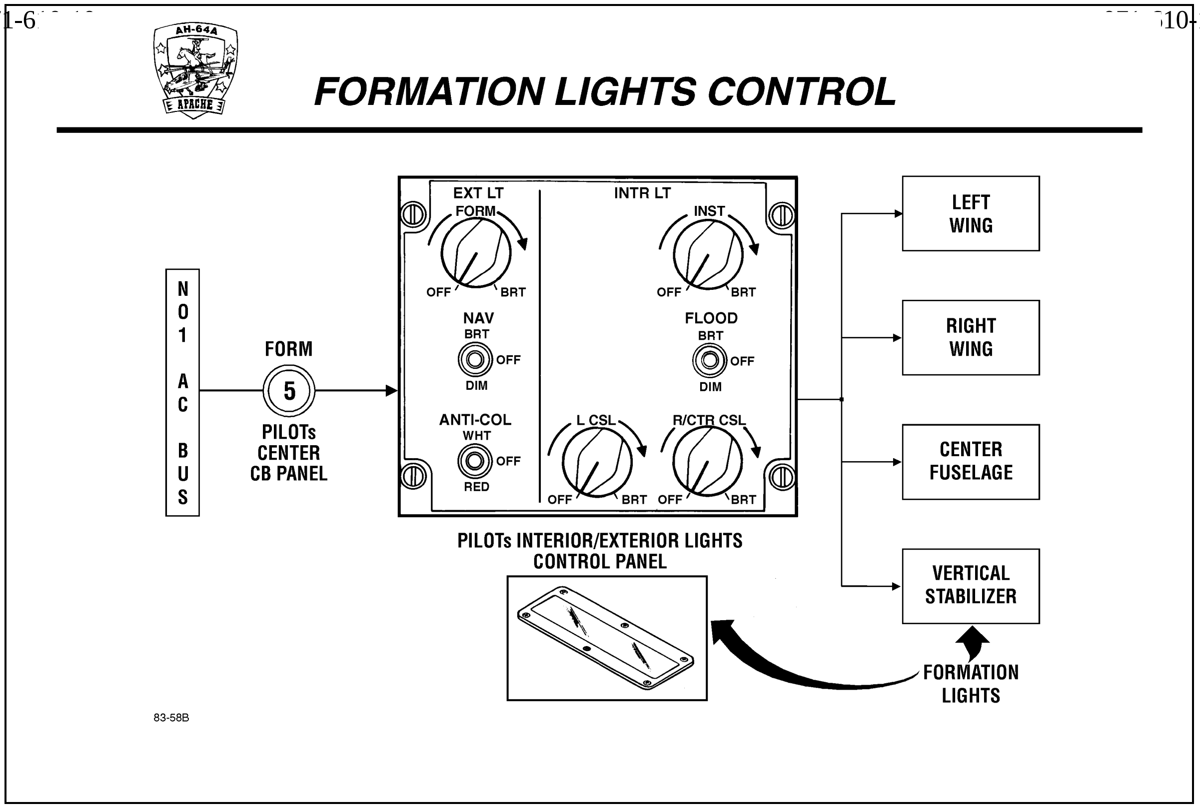
(1) Pilot's EXT LT - INTR LTS control panel

(a) The pilot's lighting control panel EXT LT section contains the following components for controlling the exterior lights.

1) FORM light rheostat.

2) ANTI-COL light three-position switch.

3) NAV light three-position switch.


AH-64A
APACHE
FORMATION LIGHTS CONTROL
NO 1 AC BUS
FORM
5
PILOTs
CENTER
CB PANEL
EXT LT
FORM
OFF
BRT
NAV
BRT
OFF
DIM
ANTI-COL
WHT
OFF
RED
INTR LT
INST
OFF
BRT
FLOOD
BRT
OFF
DIM
L CSL
OFF
BRT
R/CTR CSL
OFF
BRT
PILOTs INTERIOR/EXTERIOR LIGHTS
CONTROL PANEL
LEFT
WING
RIGHT
WING
CENTER
FUSELAGE
VERTICAL
STABILIZER
FORMATION
LIGHTS
83-58B

NOTES

2. Formation lights

a. Provide a visual indication of the helicopter position, attitude, and an indication of distance with respect to other helicopters flying in formation, at night.

b. Location

(1) On top of each wing tip

(2) One on top of the fuselage, aft of the equipment bay

(3) One on top of the vertical stabilizer

c. Are flush-mounted electro-luminescent lamp/panels.

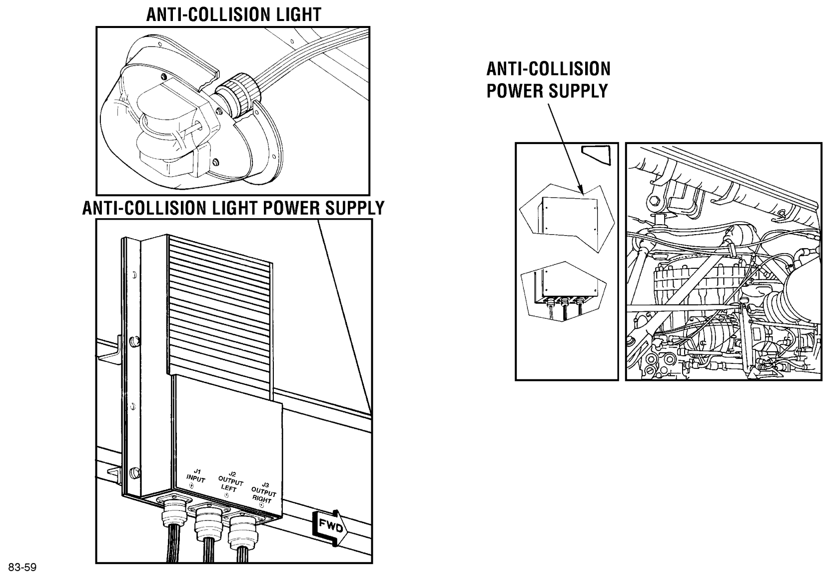
d. Operation

(1) AC essential bus 1 supplies 115 VAC, via the FORM circuit breaker on the pilot's center circuit breaker panel, to the FORM control on the pilot's interior/exterior light control panel.

(2) The FORM control on the EXT LT section of the control panel rotates out of the OFF detent, clockwise, toward the BRT position to increase the intensity of the formation lights.

071-610-10

ANTI-COLLISION LIGHT AND POWER SUPPLY



NOTES

3. Anti-collision light group

a. Give a periodic burst/strobe of high-intensity light and are used for day and night collision avoidance.

b. One on each wing tip.

c. Description

(1) Day/night high-intensity strobe lights.

(2) Each lamp assembly contains one red and one white lamp for night and day operations, respectively.

(3) The gas-filled lamps are omnidirectional. Each wing assembly flashes, alternately, at a rate of 35 times per minute.

d. The anti-collision lights receive high voltage ionizing pulses of energy from the anti-collision power supply.

e. Anti-collision light power supply

(1) Supplies high-voltage, strobe tube, anode power and trigger signals to either the red or white lamp in the anti-collision light assemblies. The assemblies consist of two flash bulb/units, a coil, reflectors, and a base mounting unit with a connector and lens.

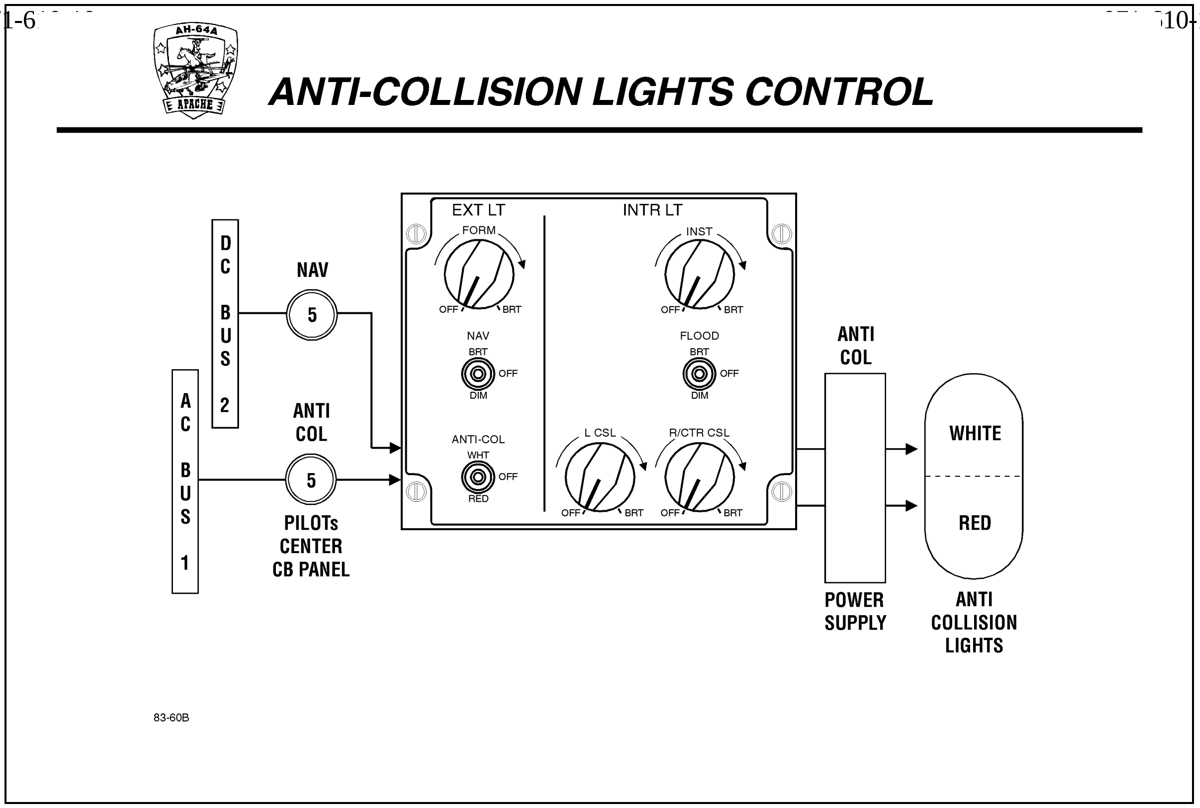
(2) The power supply is mounted on the forward, left side of the main transmission bay.

(3) Description. The power supply is an LRU that contains circuitry to transform and rectify 115 VAC into 200 volt trigger signals and 400 volt anode power and create the 35 pulses per minute, alternately between the left and right wings.

(4) Three quick-disconnect connectors are mounted on the lower side of the unit

(a) J1 input power connector

(b) J2 and J3 are interchangeable left and right wing strobe connectors, PN # M3723/76R1407N.


AH-64A
APACHE
ANTI-COLLISION LIGHTS CONTROL
DC BUS 2
AC BUS 1
NAV
5
ANTI COL
5
PILOTs CENTER CB PANEL
EXT LT
INTR LT
FORM
OFF
BRT
INST
OFF
BRT
NAV
BRT
OFF
DIM
FLOOD
BRT
OFF
DIM
ANTI-COL
WHT
OFF
RED
L CSL
OFF
BRT
R/CTR CSL
OFF
BRT
ANTI COL
POWER SUPPLY
WHITE
RED
ANTI COLLISION LIGHTS
83-60B

NOTES

(5) Operation

(a) 115 VAC from the AC essential bus 1 is applied to the ANTI-COL switch (S2) via the ANTI-COL circuit breaker.

(b) 28 VDC from the DC essential bus 2 is applied to the ANTI-COL switch (S2) via the LT NAV circuit breaker.

(c) When S2 is in the RED position, 115 VAC ONLY is applied to the anti-collision power supply. The 115 VAC is used to develop the high voltage outputs from the anti-collision power supply. These high voltages are applied to the red bulb in each anti-collision light assembly.

(d) When the ANTI-COL switch, S2, is in the WHT position, 115 VAC AND 28 VDC are applied to the anti-collision light power supply.

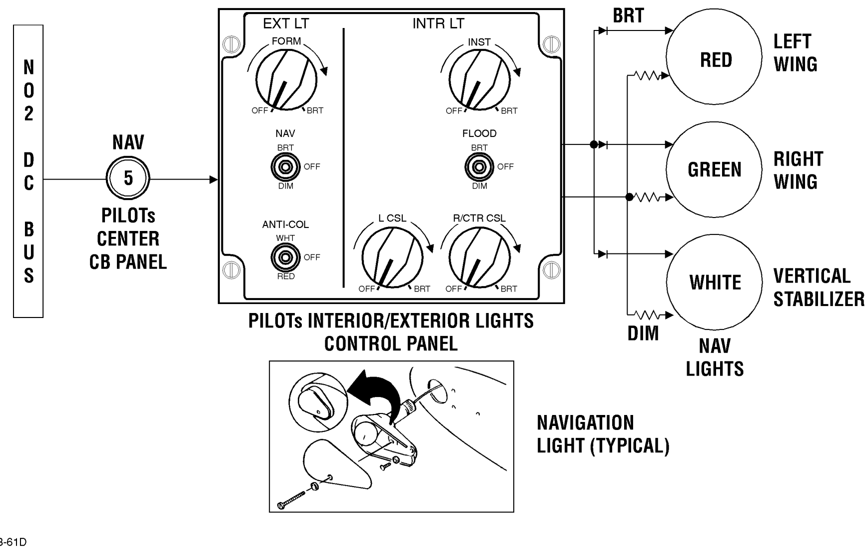
1) The 28 VDC selects white anti-collision lamp operation.

2) The 115 VAC is used to power the high voltage circuits in the anti-collision power supply.

3) These high voltages are applied to the white bulb in each anti-collision light assembly.

071-610-10

NAVIGATION LIGHTS CONTROL



NOTES

4. Navigation light group

a. Provides standard tail and wing lighting to show the helicopter's position and direction of flight to other aircraft.

b. One light assembly is mounted on each wing tip and a third assembly is mounted on the aft end of the vertical stabilizer tip-cap.

c. Description

(1) The wing navigation lights are teardrop-shaped.

(a) The left light has a red lens

(b) The right light has a green lens

(2) The tail navigation light is round and has a white lens

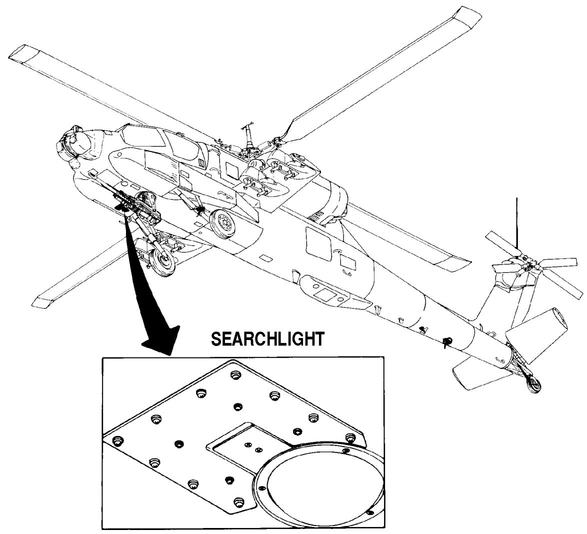
d. Operation

(1) 28 VDC from the DC essential bus 2 is applied to the NAV switch (S1) via the LT NAV circuit breaker.

(2) When the NAV switch is in the BRT position, 28 VDC is routed to the three lights through three isolation diodes mounted in the lighting control panel.

(3) When the switch is moved to the DIM position, the 28 VDC is routed through three voltage dropping resistors, also mounted in the lighting control panel. The reduction in applied power to the lamp reduces its luminance output.

LANDING / SEARCHLIGHT



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NOTES

5. Landing / searchlight

a. Provides illumination for landing, taxiing, hovering, takeoff, and search operations.

b. The light assembly is flush-mounted with the bottom of the helicopter on the right side, forward of the landing gear.

c. Description

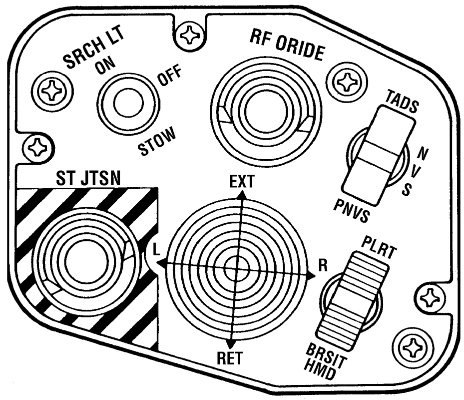
(1) The assembly consists of a lamp, a motor for extension/retraction, and a motor for rotation.

(2) The search light can extend up to 130^{o} from the flush position and rotate left and right to any desired position.

(3) The lamp has a peak rating of 400,000 candle power.

071-610-10

LANDING / SEARCHLIGHT CONTROL



83-64B

NOTES

d. Landing / searchlight controls - are located on each crewstation's collective stick switch box.

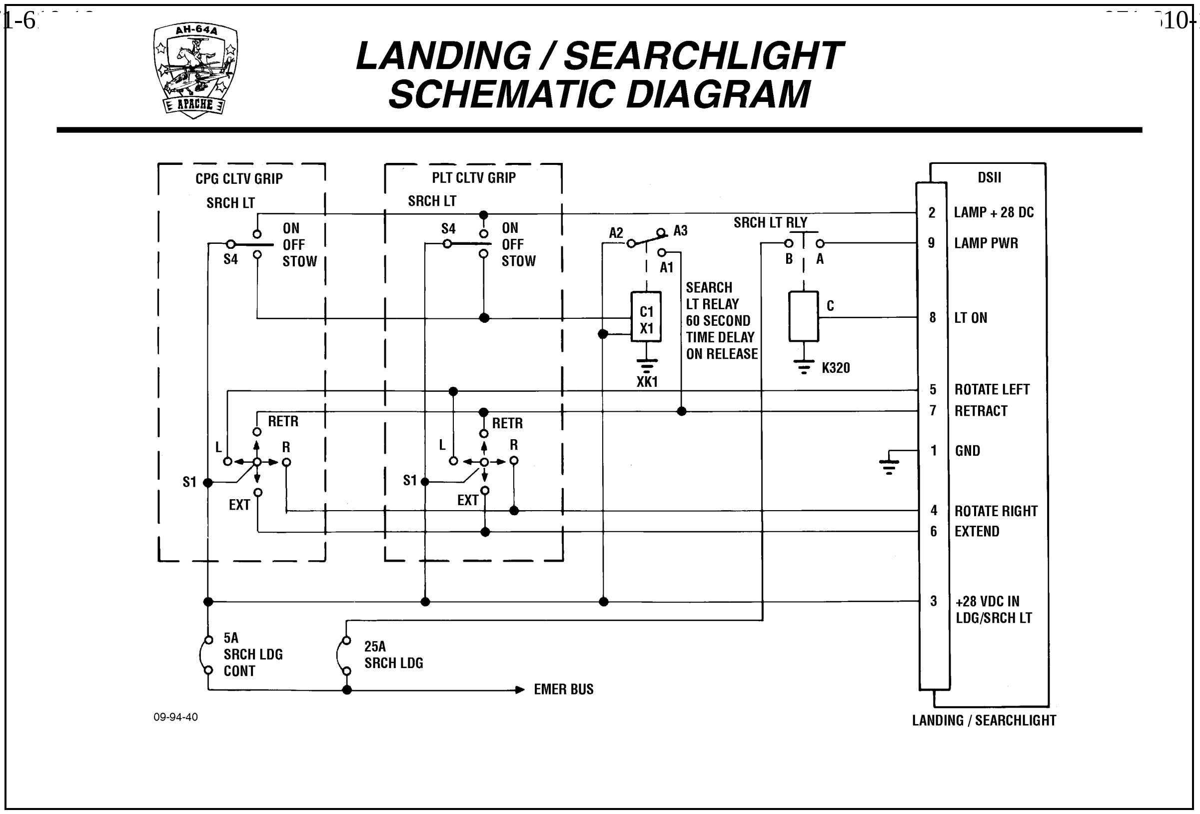
(1) The SRCH LT switch is a toggle switch that controls power to the lamp and stow circuit.

(a) When the SRCH LT switch is placed to the ON position, 28 VDC power is applied to illuminate and position the lamp.

(b) When STOW position (momentary) is selected, the light assembly retracts and rotates to the right (even if the rotation turns the unit inward to the helicopter) to reach the stow position. Cam-actuated position switches interrupt the lamp 28 VDC supply SRCH LT RLY coil voltage, via pins 2 to 8 of the lamp assembly.

(2) The EXT/RET switch is a momentary, four-position control of extension, retraction, right, and left rotation for the landing/searchlight operation.

071-610-10



NOTES

e. System operation

(1) 28 VDC emergency bus power is applied via SRCH LDG circuit breaker to pin B of relay K320 (per effectivity code [EC] [AAQ] and pin B of K1 in the landing/searchlight relay assembly (per EC [AAJ]). The normally-open contacts of the relay provides lamp power to pin 9 on the landing/searchlight in either case. This 25 amp service is used only for source power for the lamp filaments.

(2) 28 VDC emergency bus power is applied via SRCH LDG CONTR circuit breaker to

(a) Pilot and CPG SCH LT switch and EXT/RET switch.

1) SCH LT switch positions (S4)

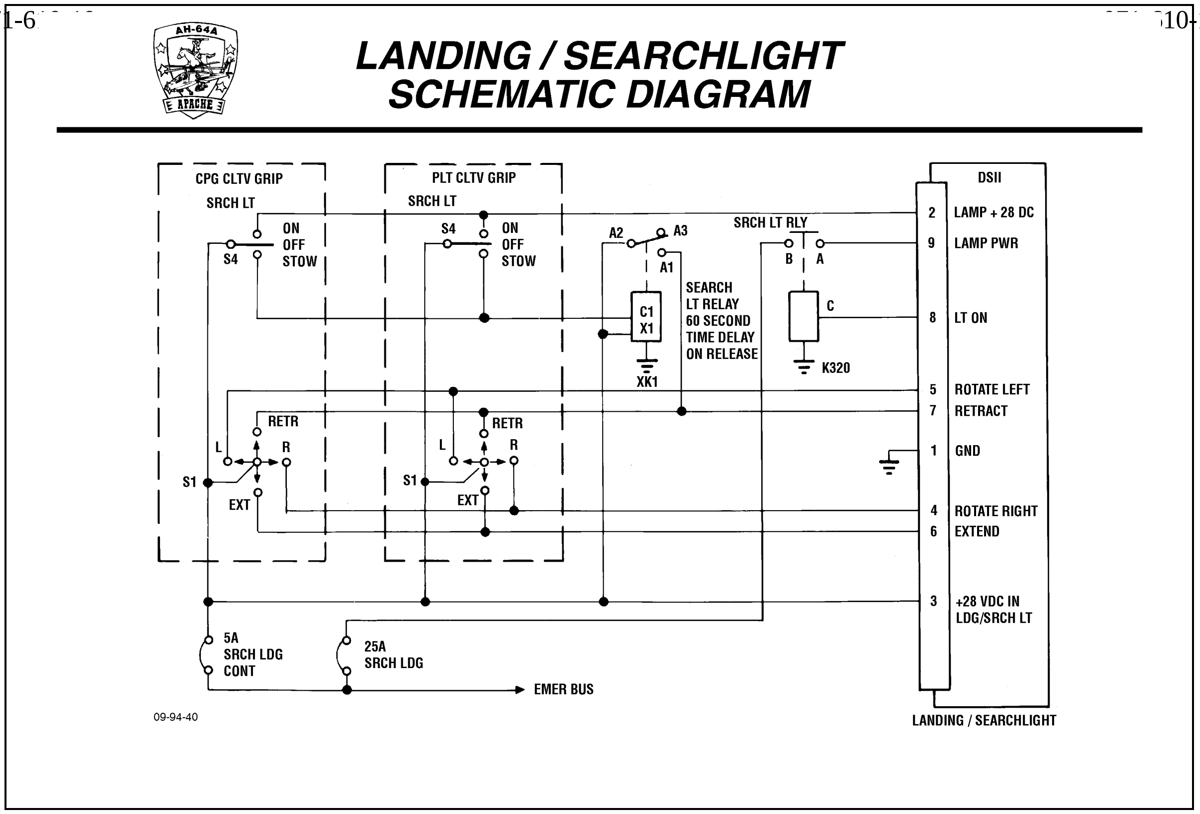
a) ON position applies 28 VDC to pin 2 of the landing/searchlight assembly through two cam-actuated micro switches (switch 4 and switch 5) and out pin 8 to energize the coil of Search light relay K320 (EC AAQ or K1 per EC AAJ). The relay applies 28 VDC to the lamp filaments.

b) OFF position extinguishes the lamp.

c) STOW (momentary) position applies 28 VDC to the coil of the time delay relay XK1. The relay's 28 VDC latched output is applied to the landing/searchlight retract motor, via a normally-closed retract position limit switch. When the switch is activated, the retraction motor de-energizes and 28 VDC retract power is applied to the light rotation motor, via the normally-closed contacts of the centering limit switch. This micro-switch interrupts power at the stow position. In the process of rotating to stow position, when/if the light turns inboard toward the fuselage, cam-operated switches 3, and 4 interrupt the coil voltage of K320, extinguishing the light until it turns outward, releasing the switches.

2) The EXT/RET/L/R switch (S1)

a) Allows the pilot to extend or retract the landing/searchlight and rotate it 360 degrees to the left or right.


AH-64A
APACHE
LANDING / SEARCHLIGHT
SCHEMATIC DIAGRAM
CPG CLTV GRIP
SRCH LT
ON
OFF
STOW
S4
RETR
L
R
S1
EXT
PLT CLTV GRIP
SRCH LT
S4
ON
OFF
STOW
RETR
L
R
S1
EXT
A2
A3
A1
C1
X1
XK1
SEARCH
LT RELAY
60 SECOND
TIME DELAY
ON RELEASE
SRCH LT RLY
B
A
C
K320
DSII
2 LAMP + 28 DC
9 LAMP PWR
8 LT ON
5 ROTATE LEFT
7 RETRACT
1 GND
4 ROTATE RIGHT
6 EXTEND
3 +28 VDC IN LDG/SRCH LT
5A
SRCH LDG
CONT
25A
SRCH LDG
EMER BUS
09-94-40
LANDING / SEARCHLIGHT

NOTES

b) When placed to the EXT position causes the extend/retract motor to drive the landing/searchlight out of stow as long as the EXT position is maintained or until the extend limit switch de-energizes the circuit.

c) When placed to the RET position the unit retracts.

d) When positioned either to R or L the unit rotates to the right or left, respectively. If the lamp is commanded to rotate L or R without being extended, limit switches will temporarily shut off the light as it rotates inward and points directly toward the fuselage.

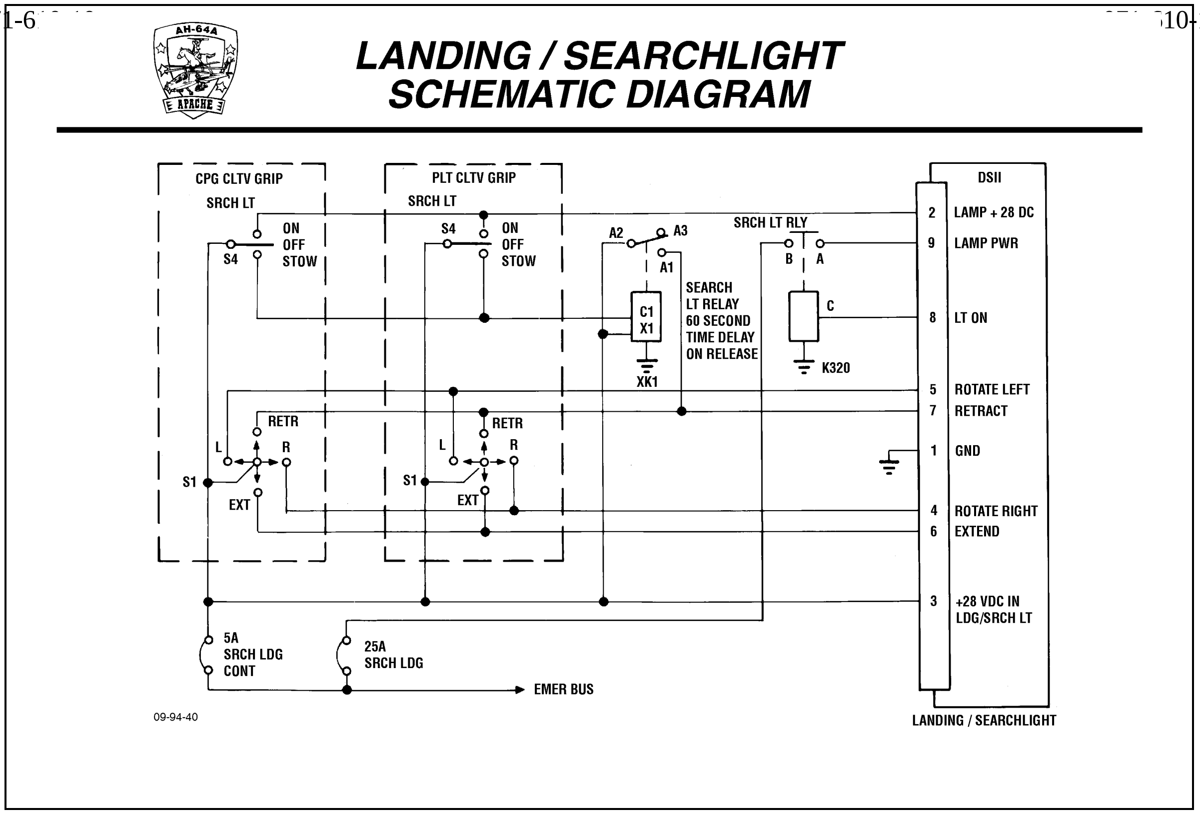
(b) Terminals A2, X1, and C1 of the searchlight time delay relay XK1

1) 28 VDC is applied to A2 as power for the retract motor when XK1 is energized.

2) 28 VDC is applied to X1 as 60 second holding power to hold the relay energized for 60 seconds to allow sufficient time for the retract motor to retract the lamp.

3) 28 VDC is applied to C1 when the SRCH LT switch is placed in the STOW (momentary) position.

a) Applying 28 VDC to C1 will cause XK1 to energize for 60 seconds which applies 28 VDC to pin 7 of DS11.


LANDING / SEARCHLIGHT
SCHEMATIC DIAGRAM
AH-64A
APACHE
CPG CLTV GRIP
SRCH LT
ON
OFF
STOW
S4
RETR
L
R
S1
EXT
PLT CLTV GRIP
SRCH LT
S4
ON
OFF
STOW
RETR
L
R
S1
EXT
A2
A3
A1
SEARCH
LT RELAY
60 SECOND
TIME DELAY
ON RELEASE
C1
X1
XK1
SRCH LT RLY
B
A
C
K320
DSII
2 LAMP + 28 DC
9 LAMP PWR
8 LT ON
5 ROTATE LEFT
7 RETRACT
1 GND
4 ROTATE RIGHT
6 EXTEND
3 +28 VDC IN
LDG/SRCH LT
5A
SRCH LDG
CONT
25A
SRCH LDG
EMER BUS
09-94-40
LANDING / SEARCHLIGHT

NOTES

b) Applying 28 VDC to pin 7 of DS11 will cause the retract limit switch to run the extend/retract motor in the retract direction until the lamp is fully retracted. The retract limit switch and the stow limit switch will then cause the L/R motor to run in the R direction until the lamp reaches the stow position, which corresponds with the lamp being flush with the fuselage, facing directly downward. The motor power is interrupted by the stow cam and micro switch and the motor stops running, leaving the lamp in the stow position.

c) If the lamp is commanded to rotate R and inward toward the fuselage, the R limit switch will temporarily shut off the light as it rotates inward and points directly toward the fuselage, until the lamp has rotated past the fuselage, at which time the light will come on again.